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ROSEVILLE
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NORTH ATLANTIC
industries, inc.

OPERATING AND INSTRUCTION MANUAL

RESOLVER SIMULATOR

MODEL 531 S-1038

NORTH ATLANTIC INDUSTRIES, INC.
Plainview New York

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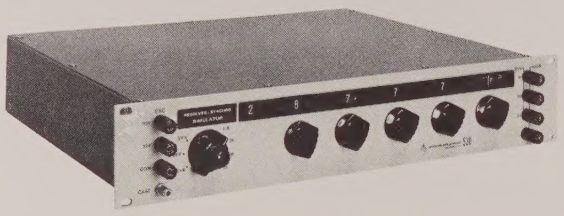
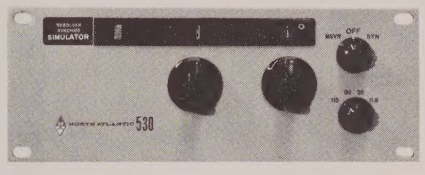


MODEL 530 - Full rack, .001° resolution, 5 knob. Rack mounted.



MODEL 530 - Half rack, 1° resolution, 2 knob. Rack mounted.

MODEL 530 - Full rack, 5° resolution, 1 knob. With retractable supports.

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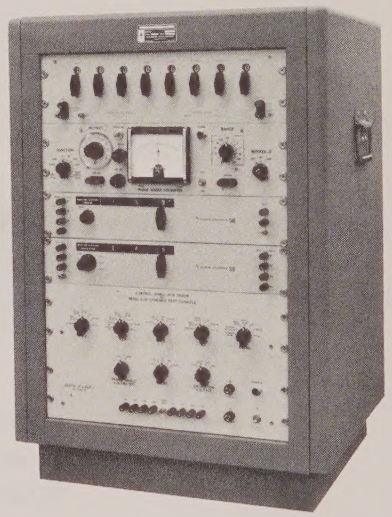

MODEL RTS 573 - Resolver/Synchro Test Console. A typical integrated test set utilizing the Model 540 Resolver/Synchro Bridge and related equipment. All tests covered in Chapter VII of this Manual can be performed readily on this equipment.

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SECTION I

GENERAL DESCRIPTION

North Atlantic Resolver/Synchro Simulators provide, in one compact 3-1/2" bench or rack-mounted unit, the ability to generate the electrical data of angular shaft position of either three-wire synchros or four-wire resolvers to an accuracy of 2 seconds of arc.* The Model 530 is a dual-mode Resolver-Synchro Simulator. Model 531 instruments are single-mode Resolver Simulators and Model 532 instruments are single-mode Synchro Simulators.

Each model meets all requirements for use in providing ideal inputs for the testing of synchro and resolver receivers, or systems under test or evaluation which operate from synchro or resolver signals. In addition to their respective mode capabilities, all standard units provide switch selected line-to-line voltages of 11.8, 26, 90, or 115 volts, from either 26V or 115V input excitation. Consequently, any of the instruments in this series may be used for testing any standard snychros or resolvers, as well as systems utilizing these components. A complete description of their use in testing resolvers and synchros of various types is covered in Section VIII.

All instruments in this series are designed to provide full accuracy at any frequency from 400 cps to 800 cps, and may be used up to 10kc with reduced accuracy. Specified accuracy is maintained for all angles over the complete range of readout. Similarly, loading erros which might arise from output impedance unbalance are minimized due to a high degree of impedance match coupled with a low output impedance.

*Accuracy of all North Atlantic Resolver-Synchro Simulators are verified by comparison to Ratio Standards which have records of calibrations traceable to the National Bureau of Standards.

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Model options for all Simulators include a 6 knob, .0001° resolution and a 5 knob, .001° resolution version for full-rack mounting. Available for half-rack or full-rack mounting are a 2 knob, 1° resolution and a 1 knob, 5° resolution version. All models have in-line display for angular decimal readout, and are continuously switched through 360°.

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SERIES 530, 531, 532
RESOLVER-SYNCHRO SIMULATORS

General Specification

The following specification applies to all North Atlantic Resolver-Synchro Simulators. Where a special modification or variation is involved, the governing specification will either be a separate specification control document, the buyer's purchase order, or a supplement contained in this manual. Specifications for special instruments are identified by the specification "S" number appearing on the instrument's nameplate.

Series 530 are dual-mode Resolver-Synchro Simulators. Series 531 are Resolver Simulators only and Series 532 are Synchro Simulators only.

Excitation:	
26 volt terminals:	.07f volt (f in cps) 35 volts maximum
115 volt terminals:	.32f volts (f in cps) 150Volts maximum
Frequency Range (within accuracy):	380 cps to 800 cps
Frequency Range (useful):	60 cps to 10kc
Output Voltage (line-to-line):	11.8, 26, 90, and 115 volts
Accuracy (Resolver and Synchro Modes):	± 2 seconds of arc or ± .00055°.

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Resolution (depending upon model):	.0001°	6 knob
	.001°	5 knob
	1°	2 knob
	5°	1 knob
Maximum Effective Output Impedance Unbalance (Ohms):	.05 + j.03	
Output/Input:	All models are isolated	
Size(All models 530,531,532):	.0001° Model (6 knob)	Full Rack
	.001° Model (5 knob)	Rull Rack
	1° Model (2 knob)	Full or HalfRack
	5° Model (1 knob)	Full or Half Rack

Full Rack:
3-1/2" Panel x 19"W x 15-1/8"D

Half Rack:
3-1/2" Panel x 9-1/2"W x 15-1/8"D

Weight (All models 530,531,532):

5°, 1/2 rack - 19 lbs. approx.
1°, 1/2 rack - 20 lbs. approx.
5°, full rack - 23 lbs. approx.
1°, full rack - 24 lbs. approx.
.001°, full rack - 29 lbs. approx.
.0001°, full rack - 30 lbs. approx.

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SECTION II

INSTALLATION

The North Atlantic Series 530 and 540 Resolver-Synchro Test Equipment are desinged for eithe rack mounting or bench use. Their compact 3-1/2" height and standard relay-rack width allow their installation into a large variety of test consoles with a minimum sacrifice of space. The all passive circuits used generate no heat and, therefore, there need be no space allocated for cooling purposes.

The bench model option consists of a standard relay rack model with the addition of a bezel and end piece assembly. For conversion to relay-rack mounting, these pieces may be removed and may be rack-mounted as shown in frontispiece.

SECTION III

OPERATING PROCEDURE

Excitation Terminals, Fuses, and Line-to-Line Level Selector

Power is applied to the Simulator at either the front or rear excitation terminals. The high side of the excitation should be applied to either the 115V or 26V excitation terminal, depending on the level being used. (See Specification Sheet for voltage limitations.) The ground side of the excitation should be attached to the terminal marked "COM". The case should be placed at ground potential by either the rack-mounting connection or a jumper from the "COM" terminal. The unit is protected by a 1 amp. and a 5 amp. fuse which are in-series with the 115V and 26V excitation lines, respectively. These fuses are located on the rear panel.

The line-to-line selector located on the front panel provides the user with a choice of four different line-to-line levels: 11.8V, 26V, 90V, and 115V, independent of mode. These levels will be obtained with either 26 volts or 115 volts excitation (applied to their respective excitation terminals).

Mode Switch and Output Terminals

The Mode Switch, located on the front panel (Model 530 only) allows the user to select synchro or resolver modes or turn the unit off. In the Snychro Mode (Models 530 & 532), three-wire synchro data is available from the synchro terminals on the rear panel, as well as from the output terminals on the front panel. In the Resolver Mode (Models 530 & 531), four-wire resolver data is available from the resolver terminals on the rear panel as well as the output terminals on the front panel. Half-rack models, unlike the full-rack versions described above, have only rear terminals.

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By utilizing the rear panel terminals, one may alternately switch from resolver to synchro operation in the Model 530 without changing terminal connections.

All Simulators have an on-off switch to facilitate changing items under test.

Decade Angle Switches and In-Line Decimal Readout

The electrical angular setting of the Simulator is adjusted by means of the angle selector knobs located on the front panel. The angle is read directly above these controls.

The first switch controls the most significant digit and advances the angle by 5^{o} steps in 5^{o} resolution models and 10^{o} steps in all others. This switch is continuous (no stops) enabling the user to go directly from $350^{o}$to 0^{o}. The secon switch controls the units of degrees from 0^{o} to 9^{o}. The third and fourth switches (in the high resolution models) control tenths and hundredths of degrees, respectively. The fifth control provides thousandths of a degree resolution.

In the $.0001^{o}$ Model 5-knob, two concentric switches are provided; the inner for increments of $.001^{o}$ with its readout in the window above the switch and an outer knob for increments of $.0001^{o}$ with its indicated setting screened on the panel.

Applications

There are many methods in which a Simulator can be used as as test instrument for the evaluation, calibration, and alignment of Resolver and Synchro components, as well as systems employing these components. The following examples are meant to serve as a guide only. Many other applications in such areas as control

circuit, phase shifters, etc., will no doubt occur to the user once familiar with the instrument's capability.

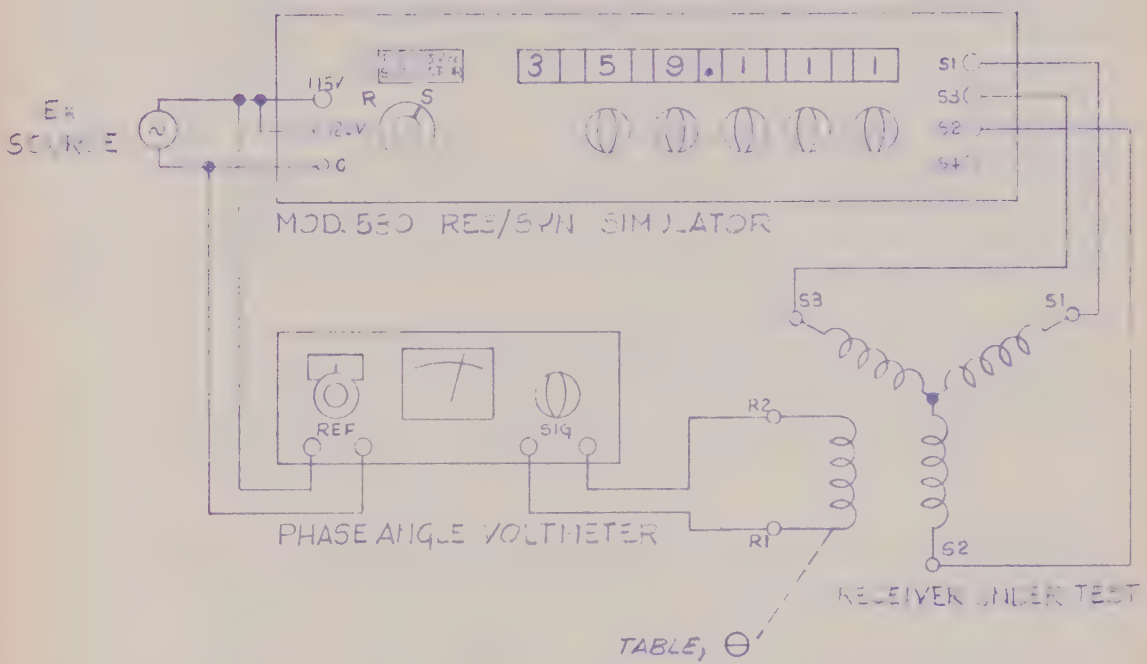


FIGURE 3
TYPICAL TEST HOOK-UP FOR TESTING A SYNCHRO CIRCUIT

Finding the Unknown Data Angle of a Receiver Type Component Using a Full Resolution Simulator

With a circuit hookup similar to that shown in Figure 3.1, adjust the Simulator angle select knobs to produce an approximately in-phase null on the Phase Angle Voltmeter. The null meter phase shifter should be set at 0^{o}.

Since the Resolver or Synchro Receiver under test will have two positions which yield an in-phase null, it is necessary to remove this ambiguity as follows:

While in the region of an approximate null, increase the angle setting of the Simulator. This will produce a more positive deflection on the Phase Angle Voltmeter, if the correct angle has been found and if conventions are in accordance with Section IV of this Manual. If the reading is negative, increase the setting of the Simulator by 180° and verify that the correct gradient polarity now occurs.

Proceed with the nulling process by using the highest increment knobs first and continuing to the least significant knob. It will be necessary to down-scale the Phase Angle Voltmeter while these adjustments are being made in order to obtain maximum sensitivity.

In the above measurement, it was indicated that the phase shifter of the null meter was set at 0° so as to produce a null in-phase with the line excitation. This method is consistent with the procedures of MIL-S-20708A.

An alternate null detector phase setting is sometimes used when the source of the null detector reference has an arbitrary phase relation to the synchros resolver excitation or where the component usage requires phasing in relation to the actual output signals. This procedure which is required by definition in MIL-R-21530C Resolvers, is as follows:

With a (0° phase) null achieved as above, switch the Simulator to maximum output (90° + reading). Up range the null meter and observe the quadrature component at as large a meter deflection as possible. Now, offset the Simulator by a large angle, but not enough to light the meter overload lamp and observe that the quadrature reading changes slightly. The Phase Dial is now re-positioned so as to restore the original quadrature

reading. This, in effect, aligns the system to make measurements in-phase with the output. Since the actual setting would vary somewhat with mechanical position of the component under test, this procedure is usually done at zero mechanical degrees of electrical zero.

Adjusting a Receiver or System to a Predetermined Angle

With the Simulator connected to provide an input to the receiver under test, set the Angle Selector Knobs so as to adjust the Simulator to the desired angle. Then adjust the receiving resolver or synchro to obtain a null on the output of the receiver as evidenced either by an external Phase Angle Voltmeter (see Figure or by some pre-established output of the system being aligned. For example, if a servo such as a North Atlantic API-8025 were being tested, the counter readout would be used to indicate the null position of the receiver shaft.

At this point, increasing the Simulator angle will cause a positive change in resolver or synchro data and in the case of a system under test will cause the system output to increase providing the system or components are wired in accordance with the conventions of Section IV. If an opposite deflection occurs, the receiver being aligned is 180° in error and should be repositioned by this amount.

Note that in systems incorporating resolvers and synchros, the conventions of Section IV are frequently altered to provide fixed offset angles or to reverse direction of rotation. The user must, therefore, verify the nature of the system's performance requirements before

interpreting the results of the foregoing test.

Using the Phase Angle Voltmeter for Measuring Receiver Angular Error

This method is frequently used in testing synchro or resolver receivers where the inputs are in the form of discreet shaft angle increments. Typically, a component under test would be mounted in a device such as a dividing head. The Simulator and dividing head would be set to 0° and the component positioned to 0° angle in the manner described in the previous paragraphs or by the electrical zero method of the applicable military specifications. Both the Simulator and the dividing head are then advanced in the desired increments. The amplitude of the null voltage as measured on the output of the receiving component is related to the error angle as follows:

$$E_{out} = K \sin \theta'$$

$$\simeq K \theta'$$

Where K is gradient of device under test

θ' is error angle of component

Since this relationship holds for small deviations at all angular settings whether the component is a resolver or a synchro, the null meter can easily be used to read a voltage which is proportioned to degrees, minutes, or seconds of arc.

As a matter of added convenience, a Phase Angle Voltmeter having a variable range attenuator will permit the user to scale the null meter sensitivity such that the

error angle can be read directly in degrees, minutes, or seconds from the meter itself.

Other Applications

See Section VIII for detailed information on testing synchro and resolver components.

SECTION IV

CONVENTIONS

Conventions for polarities, terminal designation, and direction of shaft rotation for synchros and resolvers are most frequency defined in accordance with military specifications MIL-S-20708A (synchros) and MIL-R-21530 (resolvers).

North Atlantic Bridges and Simulators all have terminal designations and electrical characteristics consistent with these same specifications. Thus, a Bridge is used as though it were a receiving component such as a control transformer (CT or RC). Likewise, a Simulator is comparable to a transmitting component (CX or RX).

In applying the conventions, caution must be exercized that:

1. The manufacturer of the synchro or resolver followed the mil-spec conventions.

2. System use of the component has not dictated a change in convention in order to achieve a difference in characteristic such as direction reversal or mechanical shaft offset.

Synchro Transmitter Conventions

Synchro Transmitter (CX)

The equations describing an ideal Synchro Transmitter (CX) apply as well to all Series 530, 532 Simulators. They are:

$$E_{(S1-S3)} = NE_{(R2-R1)} \quad \text{Sin } \theta$$

$$E_{(S3-S2)} = NE_{(R2-R1)} \quad \text{Sin } (\theta + 120^{\circ})$$

$$E_{(S2-S1)} = NE_{(R2-R1)} \quad \text{Sin } (\theta + 240^{\circ})$$

Where: $E_{(R2-R1)}$ is the voltage between rotor leads R1 and R2.

$E_{(S3-S2)}$ is the voltage between stator leads S1 and S2. Other voltages are similarly defined.

N is the ratio of the maximum rms voltage between the secondary terminals (stator) and the primary rotor voltage.

θ is the shaft angle displacement from electrical zero which satisfies these equations.

The schematic representation for a Synchro Transmitter (CX) is shown below in Figure 4.1.

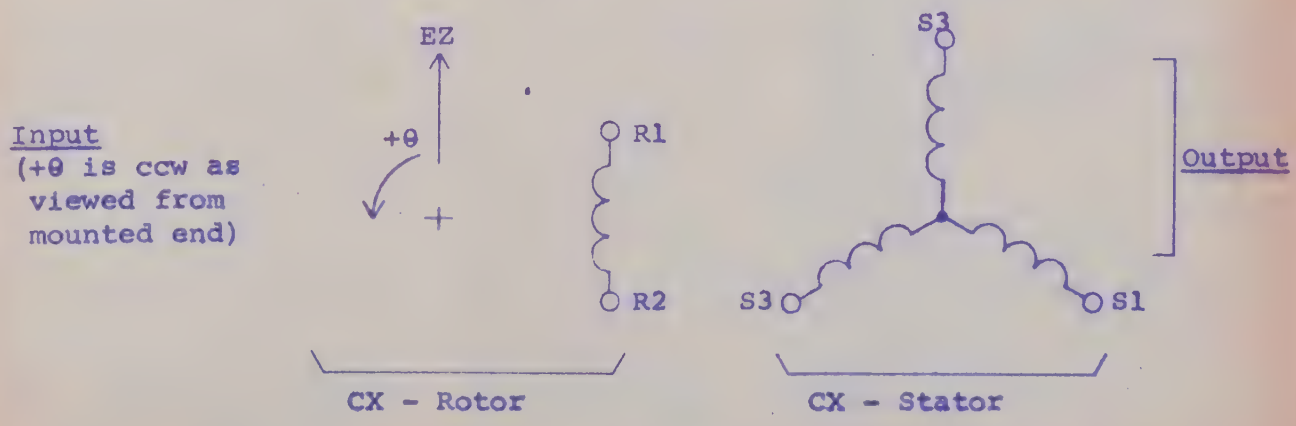
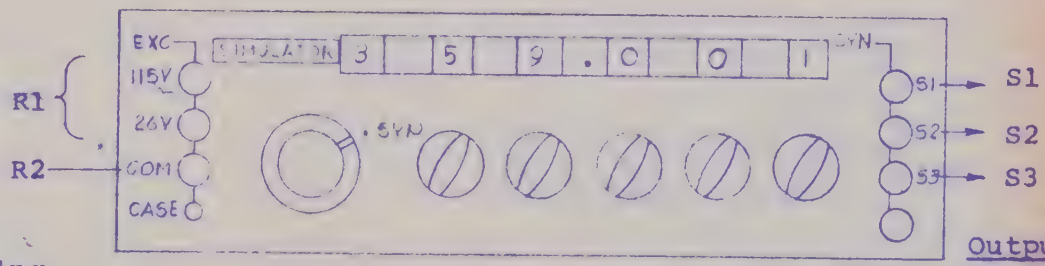


Figure 4.1. - Synchro Transmitter (at EZ) - CX

NOTE: Synchro is shown at $\theta = E_Z$ (electrical zero). This is defined as that angle for which coupled voltage between the rotor and E(S1-S3) is a minimum.

Synchro Simulator

The input and output terminals of the North Atlantic 530 and 532 Simulators correspond to the above diagram and are indicated below in Figure 4.2.



Input
From Exciting Source

Output
To Synchro CT or CDX

Figure 4.2 - Model 530 Simulator (Synchro Mode)

Synchro Receiver Convention

Synchro Receiver (CT)

The equations describing an ideal synchro receiver or control transformer (CT) apply as well to all Series 540 and 541 Bridges. They are:

$$E_{(R2-R1)} = N\left[E_{(S3-S2)}\,\mathrm{Sin}\,\theta - E_{(S1-S3)}\,\mathrm{Sin}(\theta+120)\right]$$

$$0 = E_{(S1-S3)} + E_{(S3-S2)} + E_{(S2-S1)}$$

Where: Symbols have meaning defined above.

The schematic representation for a synchro-receiver (CT) is shown below in Figure 4.3.

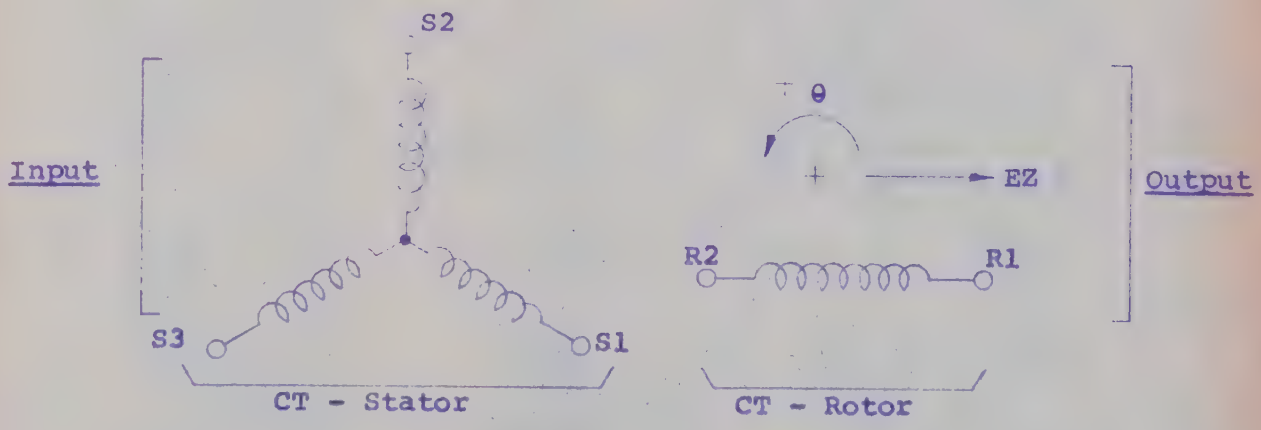


Figure 4.3 - Synchro Receiver (at EZ) - CT

NOTE: Synchro is shown at $\theta = \theta_Z$ (electrical zero). This is defined as that angle for which the coupled voltage to the rotor is a minimum when the stators are excited between S2-S1, S3.

Synchro Bridge

The input and output terminals of a North Atlantic Series 540 and 542 Bridge an analgous to those of a synchro receiver (CT). The connections which correspond to the above are shown below in Figure 4.4 .

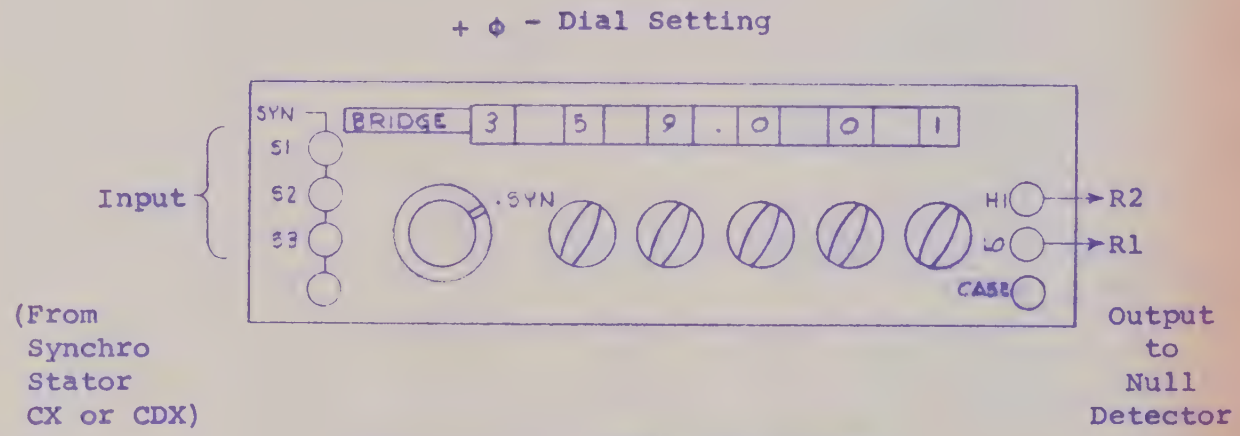


Figure 4.4 - Model 540 Bridge (Synchro Mode)

Resolver Conventions

Resolver Transmitter (RX), Control Transformer (RC), and Differential Resolver (RD).

The equation describing an ideal resolver apply as well to all Series 540 and 541 Bridges and

530 and 531 Simulators. They are:

For Rotor Energized Resolvers:

$$E_{(S1-S3)} = NE_{(R1-R3)} \text{ Cos } \theta - NE_{(R2-R4)} \text{ Sin } \theta$$

$$E_{(S2-S4)} = NE_{(R2-R4)} \text{ Cos } \theta - NE_{(R1-R3)} \text{ Sin } \theta$$

For Stator Energized Resolvers:

$$E_{(R1-R3)} = NE_{(S1-S3)} \text{ Cos } \theta + NE_{(S2-S4)} \text{ Sin } \theta$$

$$E_{(R2-R4)} = NE_{(S2-S4)} \text{ Cos } \theta - NE_{(S1-S3)} \text{ Sin } \theta$$

Where: Symbols have meaning defined above.

The schematic representation for a Resolver Transmitter (RX), Resolver Control Transformer (RC), or a Differential Resolver (RD) with the rotor excited is shown below in Figure 4.5. Input and output can be reversed for stator excited schematic.

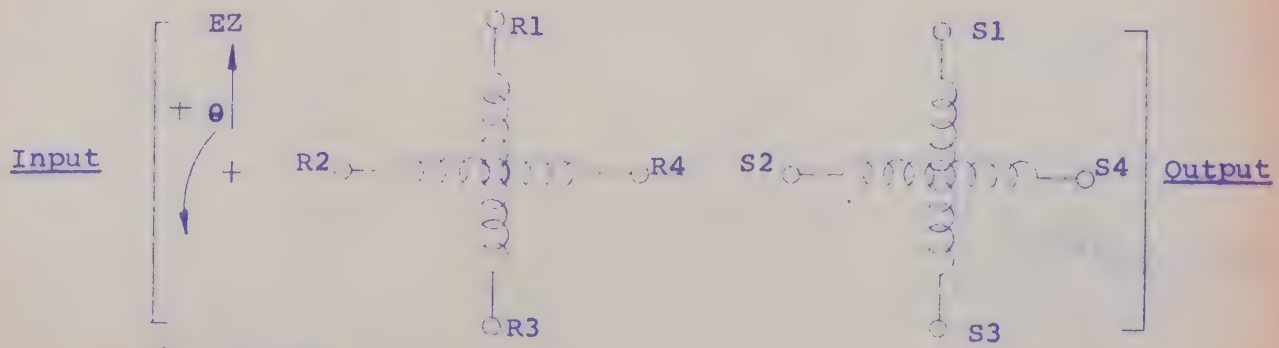


Figure 4.5 - Rotor Excited Resolver at EZ, RX, RC, or RD

NOTE: Resolver is shown at θ = EZ (electrical zero). This is defined as minimum coupling from (R1-R3) to (S2-S4) for rotor excited case. For stator excited resolver EZ is defined for minimum coupling from (S1-S3) to (R2-R4).

Resolver Simulator

The input and output terminals of a North Atlantic Series 530 and 531 Resolver Simulator are analgous to those of a rotor excited Resolver Transmitter (RX). The connections which correspond to those shown in the diagram of 4.1 are illustrated below in Figure 4.6 for a Model 530 Simulator in the Resolver Mode.

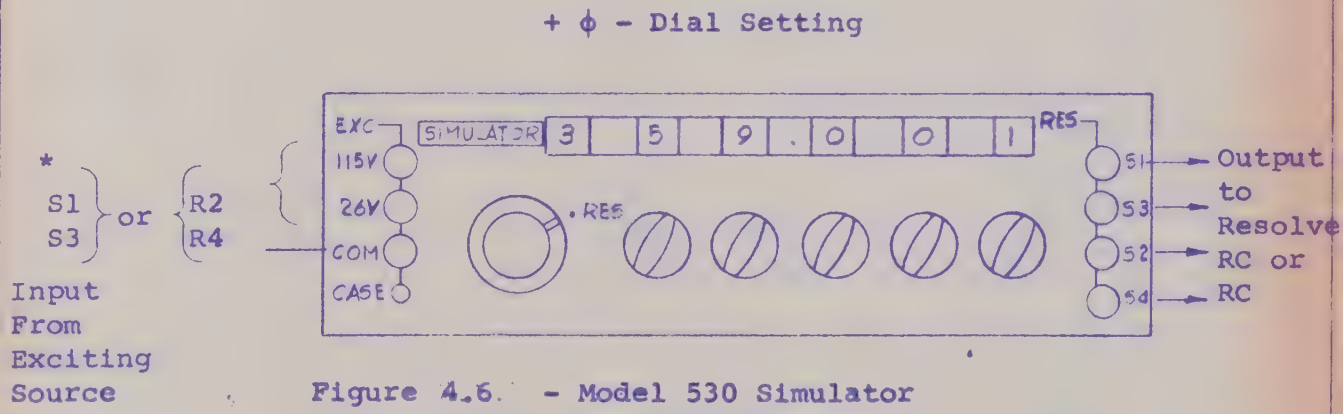


Figure 4.6 - Model 530 Simulator Resolver Mode

* NOTE: That if the Simulator is viewed as analgous to a stator excited resolver, connections to the input correspond to (S1-S3) and the output follows the numerical subscript shown.

Resolver Bridge

The input and output terminals of the North Atlantic Series 540 and 541 Resolver Bridge are analgous to those of a stator excited resolver Control Transformer (RC). The connections which correspond to those shown in the diagram of 4.1 are illustrated for a Model 540 Bridge in Figure 4.7 .

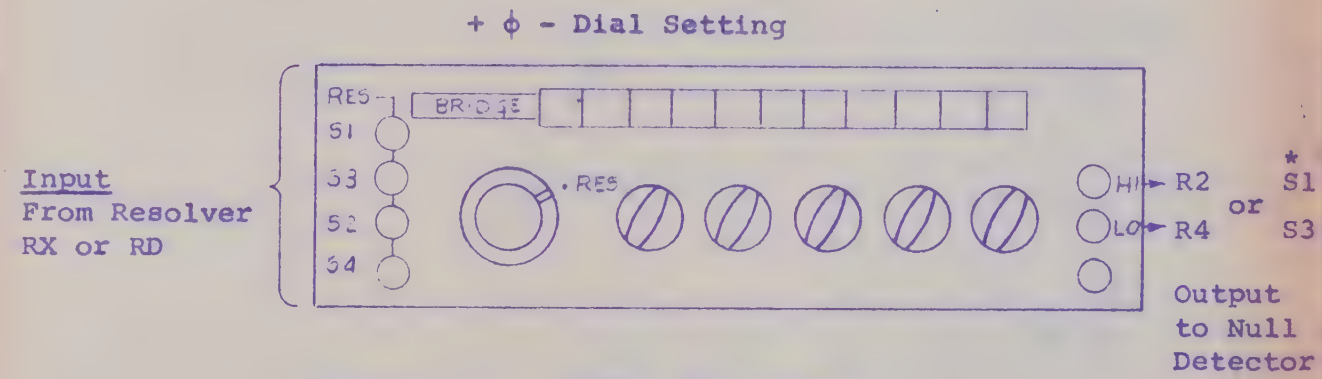


Figure 4.7 - Model 540 Bridge (Resolver Mode)

* NOTE: If the Bridge is viewed as a rotor excited analogue, connections to input follow numerical subscripts and output corresponds to (S1-S3).

SECTION V

THEORY OF OPERATION

North Atlantic Resolver and Synchro Simulators basically consist of three transformer sections. The first, or Input Selection, utilizes a tapped transformer which can be switched to provide the various line to line output voltage levels. The second section, called the Trigonometric Divider Section, produces two outputs precisely proportional to the sine and cosine of the angle selected by a series of front panel switches. The third section is a Form Converter Section which produces on the output terminals isolated synchro (3 wire) or resolver (4 wire) data at very low impedance levels.

The Model 530 Resolver-Synchro Simulator, which has all of the Transformer Sections described above, can be understood by referring to Figure 5.1.

The exciting signal 115V or 26V is applied to a tapped auto-transformer from which the desired line to line output level can be selected via Switch SA.

The output of the input voltage selection circuit is used to excite a pair of trigonometric divider sets. Each divider set produces a ratio equivalent to the sine or cosine of the angle set into the Simulator by the front panel knobs.

Each divider consists of a series of precision tapped toroidal transformers arranged in a novel circuit (patents applied for) which facilitates the precise interpolation of the angular data.

The outputs of these independent divider chains are applied in turn to the Form Converter which is comprised of several

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precisely matched toroidal transformers. The Form Converter presents as an output either 3-wire synchro data or 4-wire resolver data depending upon the circuit arrangement selected by the Mode Selector Switch SB.

Both Resolver and Synchro modes provide outputs which are isolated from the input excitation.

It is important to realize that the open circuit data output from the Simulator is defined in terms of the ratio of the output signals. For the Resolver Mode, the two outputs are:

$$E_{S1-S3} = K_1 \text{ Sin } \theta$$

$$E_{S2-S4} = K_2 \text{ Cos } \theta$$

Since $K_1 = K_2$ to an accuracy of 1 or 2ppm then:

$$\frac{E_{S1-S3}}{E_{S2-S4}} = \text{Tan } \theta$$

Thus, the output ratio defines the tangent of the selected input data angle to the accuracy specified for the instrument.

In a similar fashion, the data angle is defined for an ideal synchro in terms of the ratio of any two of the three output voltages:

$$E_{S1-S3} = K_1 \text{ Sin } \theta$$

$$E_{S3-S2} = K_2 \text{ Sin } (\theta + 120^{\circ})$$

$$E_{S2-S1} = K_3 \text{ Sin } (\theta + 240^{\circ})$$

Again, since $K_1 = K_2 = K_3$ to an accuracy of 1 or 2ppm, the ratio of any two will define the angle in accordance, for

example, with the expression:

$$\frac{E_{S1-S3}}{E_{S2-S1}} \qquad \frac{\text{Sin } \theta}{\text{Sin } (\theta + 240^{o})}$$

Note that since any two of the three synchro voltages will determine the third by Kirchoff's Law, there are, therefore, two other redundant equations relating the data angle, θ, to voltage ratios.

An important aspect of any Simulator is the effect of a load on the accuracy of the ratios just described. All North Atlantic Simulators have low nominal output impedances which minimize the effect of a load on the Simulator. Further, the design provides for a careful match of output impedance such that the effect of a load impedance is even further reduced, being related to the impedance unbalance rather than the absolute level.

The actual relationship of impedance unbalance and load is quite complex and is a function of not only the unbalance impedance, but also the data angle itself. This is apparent if it is noted that an unbalance impedance would not be equally important for all ratios; for example, in the limiting case of an angle defined by a ratio of zero, neither load impedance or unbalance impedance could change the ratio.

Series 531 and 532 Instruments

Operation of all Series 531 Resolver Simulators and Series 532 Synchro Simulators are similar to the operation of the dual-mode Model 530 Resolver-Synchro Simulator except for the presence of the Form Converter function. Isolation is provides on all models.

Switching

All North Atlantic Simulators contain inductive transformer sets which perform a basic 10° interpolation followed by succeeding decades of interpolation for 5° (in case of 5° models only), 1°, 0.1°, .01°, and .001°.

The first or 10° switch is a unique design, original in North Atlantic equipment, which links the 10° knob to both a 350° total display range and a 90° quadrant switch (not displayed). By using this technique, an in-line, non-ambiguous display of 0° to 350° in 10° increments with a direct return to zero is possible with no direction reversal and no need to mentally add dial readings.

All switches are designed with heavy-duty silver alloy buttons for long life and have transient suppression resistors mounted directly on the switch decks.

On 5°, one knob models, a special escapement mechanism is used to link a basic 10° switch (internal) to this knob which has alternate positions of 0° to 5°. Thus, whenever the position of the single knob is advanced from a 5° to 0° position or vis versa, the 10° switch is advanced or stepped back in synchronism. This arrangement is inherently self-synchronizing and cannot result in a false reading.

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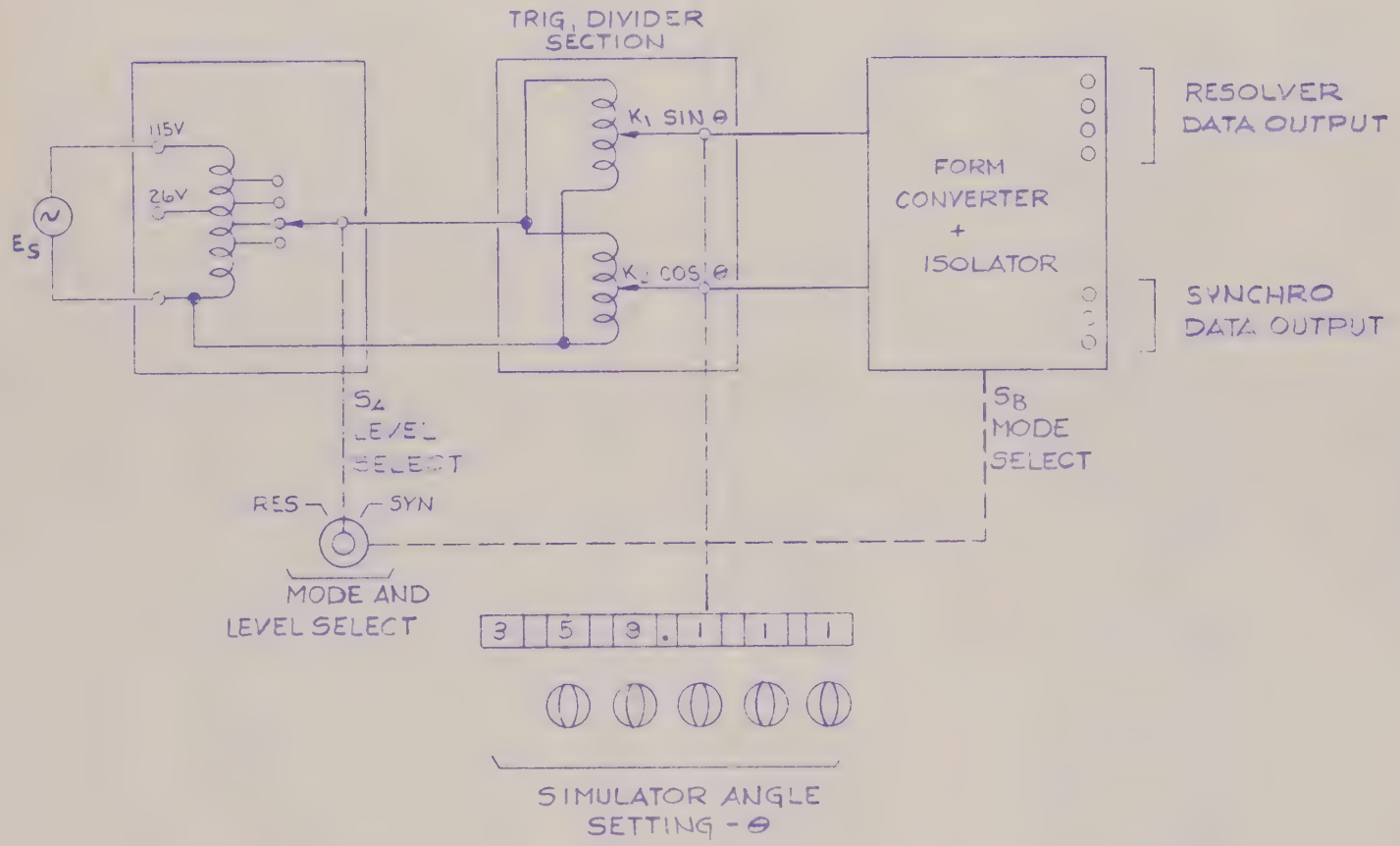

Figure 4

BLOCK SCHEMATIC OF MODEL 530
RESOLVER/SYNCHRO SIMULATOR

SECTION VI

MAINTENANCE

The North Atlantic Series 530 Resolver-Synchro Simulators contain highly accurate inductive circuits. Under normal operating conditions, the accuracy of these devices should reamin within specified tolerances indefinitely. It should be noted, however, that the application of DC to the circuits used in the 540 could result in a degradation of the operating characteristics.

Degaussing

If DC has been applied to any of the terminals in the 530, the instrument may be degaussed by attaching the circuit shown in 6.1 to all input terminal pairs in sequence. For dual-mode degaussing, the three synchro inputs will cover both modes.

With all knobs set at zero, apply the 60~ voltage to the instrument by slowing raising from zero until the point at which saturation occurs.

This will be evidenced when further increasing the setting of the Variac results in a relatively small increase in the voltage applied across the instrument. Allow the instrument to remain under the saturated conditions for a short period (typically 5 to 10 minutes). Then, slowly, over about the same period, reduce the voltage to the instrument to zero. Any residual magnetism which had been stored in the core by the DC should now be removed and the instrument should function properly. If the instrument still does not function with the specified tolerance, it should be returned to the factory.

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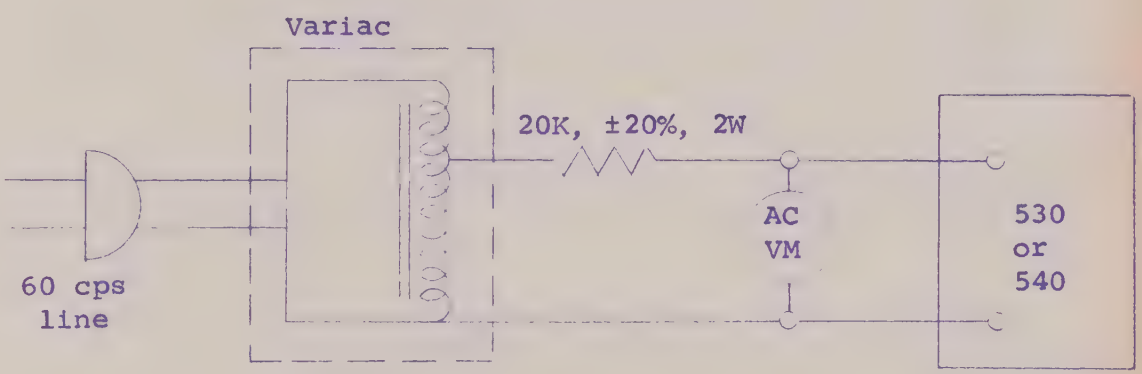

Figure 6.1

DEGAUSSING CIRCUIT

Switches

All switches used for switching critical inductive circuits are designed for long life using heavy duty alloy button contacts.

For normal maintenance, switch contacts should be cleaned with a good grade solvent, such as alcohol, and relubricated with a very thin film of clean switch lubricant, such as petroleum jelly, every 4 to 6 months of use.

If an instrument has not been used for an extended period of time, it may be desirable to cycle switches several times so as to wipe contacts clean prior to making measurement. This routine can be considered normal for an instrument of this type.

Should a precision switch need to be replaced, remove all wire connections by carefully sliding female Malco type wire connectors away from switch deck. This is readily accomplished by using a pair of long-nose pliers.

CAUTION: Do not unnecessarily remove Malco terminals since excessive disassembly may impair self-clinching characteristic of the connector.

Transformers

If a malfunction occurs which indicates that a transformer component is faulty, return the unit to the factory for overhaul and recalibration.

Calibration

Routine recalibration of a North Atlantic Simulator is normally not required except insofar as the customer quality assurance methods require these checks so as to be certain that

no random failures have caused the instrument to malfunction. Should recalibration be required, follow the procedure outlined in Section VII.

SECTION VII

CALIBRATION PROCEDURES FOR RESOLVER-SYNCHRO BRIDGES AND SIMULATORS

General

The philosophy governing the calibration of a Resolver-Synchro Inductive Simulator or Bridge and the establishing of meaningful standards involves consideration similar to those encountered in the area of AC Ratio Boxes.

In both cases, calibration data is a matter of ratio accuracy. For the Ratio Box, it is the ratio of the output to the input. For the Resolver Bridge or Simulator, it is the ratio of two AC voltages, while for a Synchro Bridge or Simulator, it is the ratio of any two of the three line-to-line voltages.

Thus, ratio is the all important measurement and herein lies the need for an appreciation of the difference between Ratio Certainty and a standard as defined by the Bureau of Standards. AC Ratio is not uniquely related to, or logically measurable in terms of, the usual physical concepts of mass, length, or time since it is a dimensionless quotient. As such, it is not traceable to any absolute electrical standard such as the ohm, volt, or ampere.

AC Ratio, by its nature, can be known to an almost unlimited degree of precision depending upon the ingenuity of the person making the measurement and the stability of the equipment used. Typically, in the area of AC Ratio measurements, measurements have been made at the National Bureau of Standards as well as in industry to precision in

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order of 0.01ppm and better. Yet, at this time, no known set of circuit elements could be assembled into a single instrument which would provide a certainty of measurement of this order of magnitude for a reasonable range of voltages, temperature, frequency, ratio, or time. This, in effect, represents the present state of art in AC ratio measurements.

Since the "technique" of AC ratio measurement is considerably better than any commercially available ratio reference, it must be readily apparent that an Inductive Ratio Box, rated at 1.0 ppm accuracy, can be evaluated or calibrated so as to provide confidence in this rating over a reasonable period of time and under the rated conditions of voltage, frequency, temperature, and ratio range. The National Bureau of Standards provides such a calibration service and evidences their calibration in the form of a record of calibration as of the time the ratios were measured. It remains for the user and manufacturer to determine the period over which confidence in this rating can be maintained.

It is the experience of North Atlantic, over a period of many years, that a properly maintained Inductive Ratio device such as a Ratio Box, Bridge, or Simulator, will sustain its ratio accuracy to a confidence level of well under 1.0 ppm for a period of many years.

Simulator and Bridge Calibration

In the procedure to follow, a technique for calibrating both Resolver-Synchro Simulators and Bridges is presented which follows the philosophy just described. Through use of a Ratio Reference such as a 1.0ppm, North Atlantic RB-504 Ratio Box, it is merely a matter of

technique by which both Bridges and Simulators can be calibrated to a level of confidence comparable to the Ratio Reference itself. Noting that an uncertainty in ratio, equivalent to ± 1.0 ppm (against unity ratio) is, in the worse case, equivalent to an angular uncertainty of only ± 0.2 arc second, it is apparent that a high degree of confidence can be expected in the ultimate calibration data for Resolver and Synchro Bridges and Simulators.

It should be noted that the 1.0 ppm terminal linearity rating of the RB-504 Ratio Box is certifiable by North Atlantic against a factory standard which, in turn, has a record of calibration issued by the National Bureau of Standards.

Calibration Period and Method

The frequency of calibration required for Resolver-Synchro Bridges and Simulators is necessarily dictated by the application and the established policies of the user. Since the construction of all North Atlantic Bridges and Simulators uses heavy-duty switches and quality torroidal transformers, it is recommended that full calibration (calibration Procedure II) will only infrequently be required. However, where Quality Control procedures require routine checks to make certain that no random equipment failures have occurred, the simpler Calibration Procedure I may be used.

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CALIBRATION PROCEDURE I

General

This procedure can be used to calibrated on a GO-NO-GO basis either a Bridge or a Simulator. The validity for this type of comparison can be taken as the sum of the rated Bridge error and the rated Simulator error or ± 4 arc seconds. The procedure is recommended as a routine Quality Control Calibration to verify proper operation of the equipment.

Equipment Required

One - Reference Bridge or Simulator

Typical Resolver-Synchro Bridge Model 540, 5 knob, .0001° resolution or typical Resolver-Synchro Simulator Model 530, 6 knob, .0001° resolution.

One - Phase Angle Voltmeter

Model 202BRT, with high sensitivity (300uv or 10uv), plus variable range adjustment.

One - Adjustable Source of 400~ AC Voltage

Procedure

Connect equipment as shown in Figure 7.1 and proceed as follows:

A. Using appropriate Reference Simulator or Bridge, adjust all knobs to read zero on both the test item and the reference equipment.

B. Adjust supply to 26V or 115V, 400~ depending upon Simulator input terminal used.

C. Adjust the Phase Angle Voltmeter to read an in-phase null (see Operating Instructions in this manual, Section III).

D. Offset either the Simulator or Bridge by 0.02° or 72 seconds. Select convenient meter range where range vernier will permit adjustment of reading to 72 on X10 scale. Meter is now appropriately scaled to measure the deviation between the Bridge and Simulator directly in seconds by ranging to any convenient scale.

E. Track both Simulator and Bridge through desired calibration angles, noting that readings all fall within ± 4 arc seconds.

If in Step E above, readings fall outside the ± 4 second spread, recheck operation of the Phase Angle Voltmeter and test circuit to be certain the hookup is correct and that no ground loops, unground terminals, etc., exist. If the out of tolerance reading is reaffirmed, proceed to the more elaborate Calibration Procedures II.

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CALIBRATION PROCEDURES II

General

The Calibration Procedure II is designed to provide what might be thought of as an "ideal" calibration. In the case of a Bridge, means are taken to eliminate any errors due to loading of the source impedances by the Bridge. In the case of the Simulator, the calibration method closely approximates the conditions of a Simulator driving a high impedance load, thereby providing an "ideal" open-circuit accuracy.

The procedure is arranged in two parts. The first covers the calibration of a Resolver Bridge and a Synchro Bridge to a ratio measurement validity of approximately ± 1.0ppm or the equivalent of a ±0.2 arc seconds.

The second part of this procedure makes use of a Bridge calibrated in accordance with the above. The Bridge is then used as a calibrated transfer reference against which a Resolver or Synchro Simulator can be calibrated. This procedure results in a validity of calibration of approximately ± 0.4 arc seconds for a Simulator.

A word of caution should be made regarding the use of alternate methods of calibration such as those using a resistance Bridge or methods utilizing single Ratio Box techniques. Although good results may be obtainable, insidious errors due to impedance loading,

phase shift, etc., are easily overlooked. The procedures described are recommended principally because the simplicity of the setup does not need a particularly high degree of "ingenuity" or experience to achieve the accuracy sought.

Resolver Bridge Calibration

The following procedure can be used to calibrate all Model 540 and 541 Resolver Bridges.

Equipment Required

Two - 10ppm Ratio Boxes, North Atlantic Model RB503

One - 1.0ppm Ratio Box, North Atlantic Model RB504

One - Shielded Bridge - Null Transformer, North Atlantic Model T110

Two - Phase Angle Voltmeters, Model 202BRT with high sensitivity (300uv or 10uv)

Two - DPDT Switches

One - Adjustable Source of 400~ AC Voltage

Procedure

Connect the Equipment as shown in Figure 7.2. Note that in this arrangement, Ratio Boxes RB-1 and RB-2 will servo to generate resolver voltages suitable for driving the inputs of the Bridge being calibrated.

Since these Boxes have finite output impedances which vary with ratio settings, some loading errors can be expected due to the input impedance of the Bridge being tested.

To correct for this loading error, the 1.0ppm RB-504 designated RB-S is used as a precision ratio transfer device. Ratios can be set up on RB1 and RB2 while under load. The Bridge Null Transformer and Phase Angle Voltmeter - No. 1, are used to make the comparison between the Ratio Reference, RB-S, and the driving Ratio Boxes, RB1 and 2.

Proceed as follows:

A. Adjust Variac T-1, or variable source for desired line-to-line voltage (90, 11.8, etc) to accuracy of ± 5%.

B. Adjust Phase Angle Voltmeter - No. 1 for making an in-phase null (0^{o}).

C. With Resolver Bridge under test set at the angle being calibrated, set RB-S to desired sine (RB-2) ratio, using values from Tables I, II, III, and IV.

D. Connect Null Transformer lead "A" to the output of the Box RB-2 and adjust for null on the Phase Angle Voltmeter - No. 1. Set to resolution of at least 1/3ppm.

E. Repeat Steps C and D for setting of Box RB-1.

F. Input to Bridges is now accurate to within ± .2 sec. Now adjust Bridge to achieve in-phase null on Phase Angle Voltmeter - No. 2. Calibration angle is read from Bridge and recorded.

G. Repeat Steps C through F for each angle to be calibrated. Note that Tables I through IV are given for the most commonly tested angles.

Synchro Bridge Calibration

Equipment Required

Two - 10ppm Ratio Boxes, North Atlantic Model RB503

One - 1.0ppm Ratio Box, North Atlantic Model RB504

One - Shielded Bridge Null Transformer, North Atlantic Model T110

Two - Phase Angle Voltmeters, North Atlantic Model 202BRT, with high sensitivity, 300uv or 10uv.

Three - SPTT Switches

One - Adjustable Source of AC Voltage

Procedure

Connect the equipment as shown in Figure 7.3. Note that in this arrangement Ratio Boxes RB-1 and RB-2 will serve to generate synchro input voltages suitable for driving the inputs of the Bridge being calibrated. Since these Boxes have finite output impedances which vary with ratio settings, some loading errors can be expected due to the input impedance of the Bridge being tested.

To correct for this loading error, the 1.0ppm RB-504 designated RB-S is used as a precision ratio transfer device by which the proper voltage ratios can be set up on RB-1 and 2 while under load. The Bridge Null Transformer and Phase Angle Voltmeter - No. 1, are used to make the comparison between the Ratio Reference RB-S and the driving Ratio Boxes RB-1 and 2.

Proceed as follows:

A. Adjust Variac T-1, or variable source for desired line-to-line voltage (90, 11.8, etc.) to accuracy of ± 5%.

B. Adjust Phase Angle Voltmeter - No. 1, for making an in-phase null (0^{o}).

C. With Synchro Bridge under test set at the angle being calibrated, set RB-S to desired setting of RB-2 obtained from Tables V, VI, VII, and VIII.

D. Connect Null Transformer lead A to the output of Box RB-2 and adjust same for null on Phase Angle Voltmeter - No. 1, set to resolution of at least 1/3ppm.

E. Repeat Steps C and D for setting on RB-1.

F. Input to Bridge is now accurate to within ± .2 seconds. Now adjust Bridge to achieve in-phase null on Phase Angle Voltmeter - No. 2. Calibration angle is read from Bridge and recorded.

G. Repeat 3 through 6 for each angle to be calibrated. Note that Table V through VIII are given for the most commonly tested angles.

Simulator Calibration

Equipment Required

One - Phase Angle Voltmeter, North Atlantic Model 202BRT with high sensitivity, 300uv to luv and range vernier option.

One - Calibrated Bridge, type to cover mode of operation desired, North Atlantic Model 540, 5 knob, .0001° resolution.

One - Adjustable 400~ AC Voltage Source

Procedure

Connect equipment as shown in Figure 7.1. The technique used in calibrating a Simulator consists in comparing the Simulator under test to a Bridge calibrated in accordance with the methods previously outlined.

The technique is indentical tothat for a Calibration Procedure I. Comparison can be made by the deviation method described under Calibration Procedure I or by nulling using either the calibrated Bridge or the Simulator under test. The calibration

error, of course, would be the combination of the calibration data for Bridge plus the deviation of the Bridge and Simulator as measured in this test.

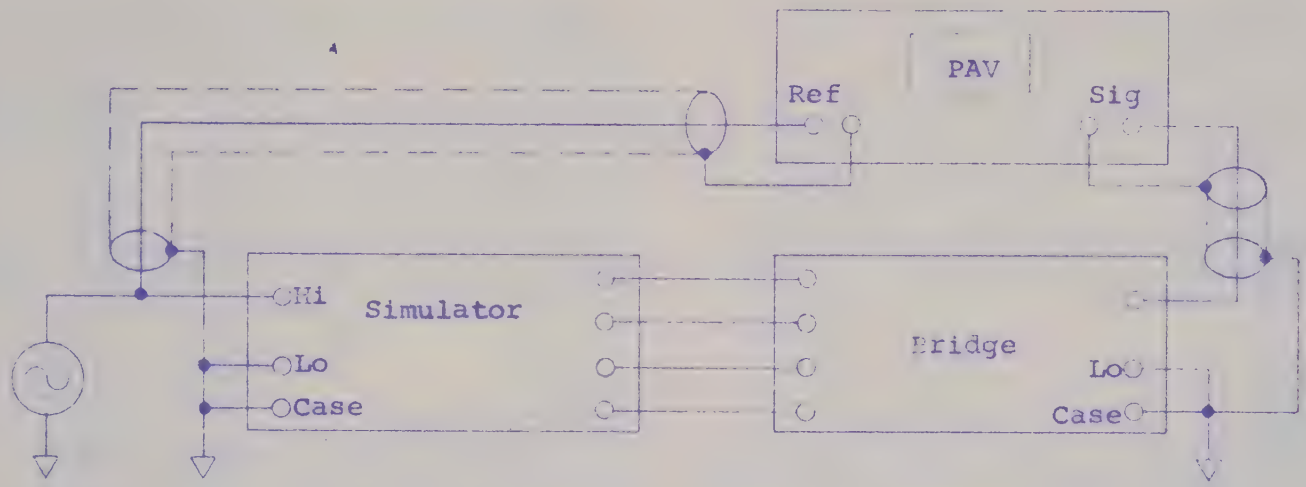

Figure 7.1- Calibration Circuit

Calibration I Procedure-Bridge or Simulator
Calibration II Procedure-Simulator Only

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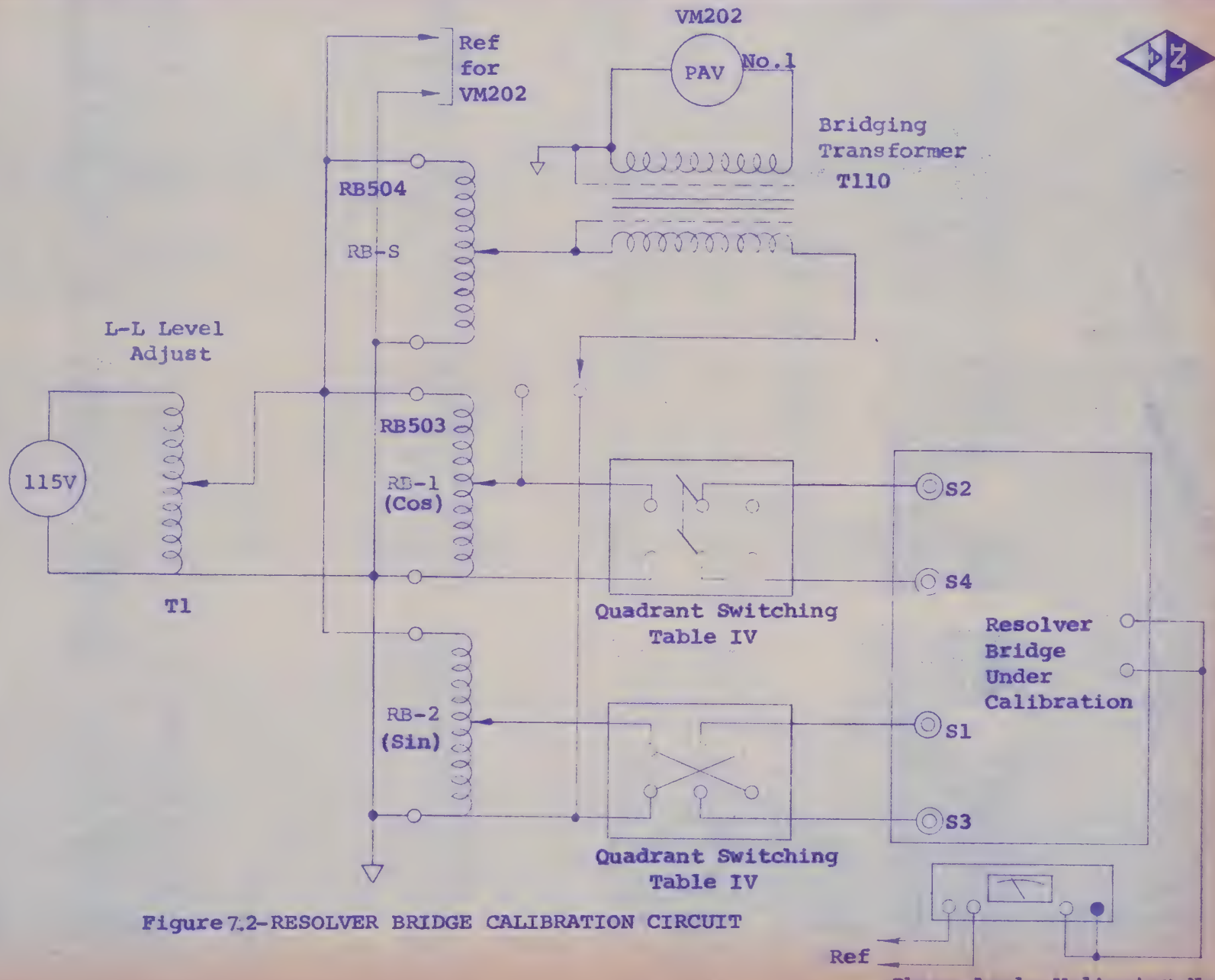

Figure 7.2-RESOLVER BRIDGE CALIBRATION CIRCUIT

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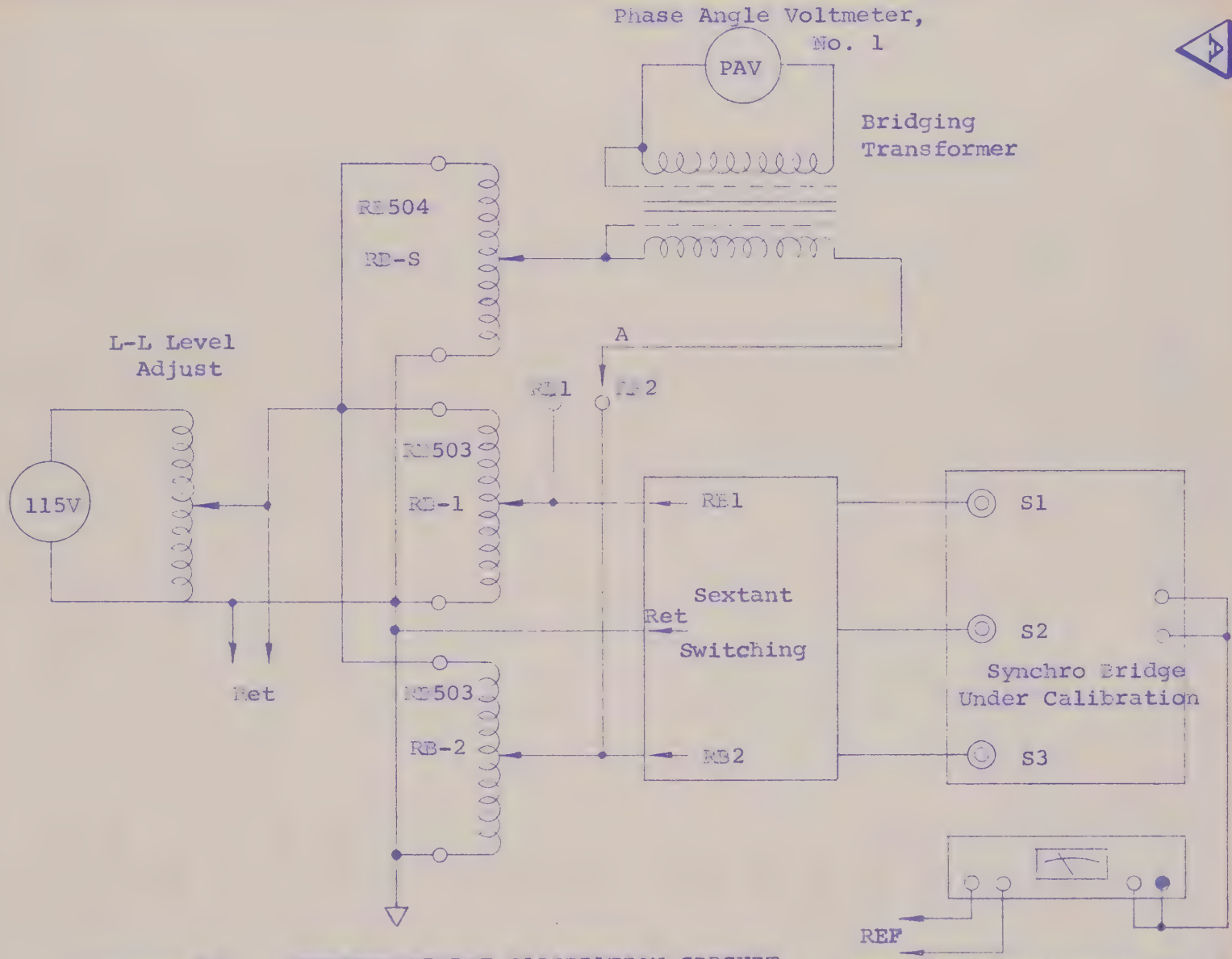

Figure 7.3 - SYNCHRO BRIDGE CALIBRATION CIRCUIT

TABLE I

RESOLVER CALIBRATION CHART

I	II	III	IV	RB1	RB2
0	180	180	360	1.0000000	.0000000
5	175	185	355	.9961946	.0871557
10	170	190	350	.9848077	.1736480
15	165	195	345	.9659258	.2588190
20	160	200	340	.9396926	.3420201
25	155	205	335	.9063077	.4226182
30	150	210	330	.8660254	.5000000
35	145	215	325	.8191520	.5735764
40	140	220	320	.7660444	.6427876
45	135	225	315	.7071067	.7071067
50	130	230	310	.6427876	.7660444
55	125	235	305	.5735764	.8191520
60	120	240	300	.5000000	.8660254
65	115	245	295	.4226182	.906377
70	110	250	290	.3420201	.9396926
75	105	255	285	.25588190	.9659258
80	100	260	280	.1736480	.9848077
85	95	265	275	.0871557	.9961946
90	90	270	270	.0000000	1.0000000

TABLE II

RESOLVER CALIBRATION CHART

	RB1 (Cos)	RB2 (Sin)
40.000	.7660444	.6427876
41.000	.7547096	.6560590
42.000	.7431448	.6691306
43.000	.7313537	.6819984
44.000	.7193398	.6946584
45.000	.7071068	.7071068
46.000	.6946584	.7193398
47.000	.6819984	.7313537
48.000	.6691306	.7431448
49.000	.6560590	.7547096
40.1	.7649214	.6441236
40.2	.7637960	.6454577
40.3	.7626683	.6467898
40.4	.7615383	.6481199
40.5	.7604060	.6494480
40.6	.7592713	.6507742
40.7	.7581343	.6520984
40.8	.7569951	.6534206
40.9	.7558535	.6547408

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TABLE III

RESOLVER CALIBRATION CHART

Angle	RB1 (Cos)	RB2 (Sin)
40.01	.7659322	.6429213
40.02	.7658200	.6430550
40.03	.7657078	.6431886
40.04	.7655955	.6433223
40.05	.7654832	.6434559
40.06	.7653709	.6435895
40.07	.7652586	.6437230
40.08	.7651461	.6438566
40.09	.7650338	.6439901
40.001	.7660332	.6428010
40.002	.7660220	.6428143
40.003	.7660107	.6428277
40.004	.7659995	.6428411
40.005	.7659883	.6428545
40.006	.7659771	.6428678
40.007	.7659659	.6428812
40.008	.7659546	.6428946
40.009	.7659434	.6429073

TABLE IV

RESOLVER CALIBRATION

QUADRANT SWITCHING TABLE

Quadrant	Angle	Hi	Lo	Hi	Lo
I	0-90	S2	S4	S3	S1
II	90-180	S4	S2	S3	S1
III	180-270	S4	S2	S1	S3
IV	270-360	S2	S4	S1	S2

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TABLE V

SYNCHRO CALIBRATION CHART

I	II	III	IV	V	VI	RB1	RB2
0°	120°	120°	240°	240°	360°	.8660254	.000000
5°	115°	125°	235°	245°	355°	.9063077	.0871557
10°	110°	130°	230°	250°	350°	.9396926	.173648
15°	105°	135°	225°	255°	345°	.96599258	.2588190
20°	100°	140°	220°	260°	340°	.9848077	.3420201
25°	95°	145°	215°	265°	335°	.9961946	.4226182
30°	90°	150°	210°	270°	330°	1.0000000	.5000000
35°	85°	155°	205°	275°	325°	.9961946	.5735764
40°	80°	160°	200°	280°	320°	.9848077	.6427876
45°	75°	165°	195°	285°	315°	.9659258	.7071067
50°	70°	170°	190°	290°	310°	.9396926	.766044
55°	65°	175°	185°	295°	305°	.9063077	.8191520
60°	60°	180°	180°	300°	300°	.8660254	.8660254

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TABLE VI

SYNCHRO CALIBRATION CHART

Angle	RB1 (Cos)	RB2 (Sin)
40	.9848077	.6427876
41	.9816272	.6560590
42	.9781476	.6691306
43	.9743701	.6819984
44	.9702957	.6946584
45	.9659258	.7071067
46	.9612617	.7193398
47	.9563048	.7313537
48	.9510565	.7431448
49	.9455186	.7547096
40.1	.9845032	.6441236
40.2	.9841956	.6454577
40.3	.9838850	.6467898
40.4	.9835715	.6481199
40.5	.9832549	.6494480
40.6	.9829353	.6507742
40.7	.9826128	.6520984
40.8	.9822873	.6534206
40.9	.9819587	.6547408

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TABLE VII

SYNCHRO CALIBRATION CHART

Angle	RB1 (Cos)	RB2 (Sin)
40.01	.9847774	.6429213
40.02	.9847471	.6430550
40.03	.9847167	.6431886
40.04	.9846863	.6433223
40.05	.9846558	.6434559
40.06	.9846254	.6435895
40.07	.9845949	.6437230
40.08	.9845643	.6438566
40.09	.9845338	.6439901
40.001	.9848047	.6428010
40.002	.9848016	.6428143
40.003	.9847986	.6428277
40.004	.9847956	.6428411
40.005	.9847926	.6428545
40.006	.9847895	.6428678
40.007	.9847865	.6428812
40.008	.9847835	.6428946
40.009	.9847804	.6429073

TABLE VIII

SYNCHRO CALIBRATION

SEXTANT SWITCHING CHART

		RB1		RB2
Sextant	Angle	Hi	Ret	Lo
I	0-60	S2	S1	S3
II	60-120	S3	S1	S2
III	120-180	S3	S2	S1
IV	180-240	S1	S2	S3
V	240-300	S1	S3	S2
VI	300-360	S2	S3	S1

SECTION VIII

ROTARY COMPONENT MEASUREMENT

The following is a detailed step-by-step procedure for precise test of the most commonly encountered types of synchros and resolvers.

I. Synchro Transmitter (CX) Test

A. Phasing, Electrical Zero, and Angular Accuracy

1. Connect CX, 540, and PAV as shown in schematic. Rotate CX shaft counterclockwise as viewed from shaft end until PAV reads zero. Note that the meter approaches 0 from left to right. For 115V excitation, use 100V range of the voltmeter.

2. With synchro shaft at the null point, switch 540 to 5°. The voltmeter should deflect to the left. Set 540 back to 0.

3. If the requirements of Steps 1 and 2 are met, the phase is correct, and the null point is electrical zero.

4. Mount CX in a dividing head.

5. With the dividing head at 0, CX must be at electrical zero, as described in Steps 1 and 2.

6. Set voltmeter Function Selector to 90°.

7. Set 540 to 90°.

8. Rotate Phase Dial on the voltmeter until a quadrature null is reached.

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9. The angle read on the Phase Angle Dial is approximately equal to the phase shift of the CX.

10. With the Phase Dial at this setting, return 540 and the Function Selector to 0°.

11. Re-zero CX in dividing head if necessary.

12. With the CX at 0, offset the dividing head an amount equal to the maximum allowable error of the CX.

13. Down scale the Range Selector until the first off-scale meter reading is reached. Turn the Range Selector to the next up-scale range. Record the deflection on the PAV. This is the maximum allowable error voltage.

14. Return the dividing head to 0°.

15. Advance the 540 and the dividing head in the required increments. The null error, as noted on the PAV, should be less than that obtained in Step 13.

B. Null Test, "Total" and "Fundamental"

1. With the CX still mounted in the dividing head, set up circuit indicated.

2. Rotate the dividing head to 120°.

3. Set the voltmeter Function Selector to 0°, and adjust the dividing head for a null.

4. Read the nulls in both Total and Fundamental.

5. Attach PAV leads to S2 and S3, and rotate the dividing head to 240°.

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6. Repeat Steps 3 and 4.

7. Attach PAV leads to S1 and S3, and rotate the dividing head to 0°.

8. Repeat Steps 3 and 4.

C. Transformation Ratio Test

1. Turn Phase Angle Dial to 0°.

2. With the CX still mounted in a dividing head, set up the circuit indicated.

3. Set Function Selector to 0°.

4. Set the dividing head to 30°, and adjust Ratio Box for a null. Record ratio reading (transformation ratio).

D. Phase Shift Test

1. With the CX still mounted in the dividing head, set up circuit indicated.

2. Switch voltmeter Function Selector to 90° position.

3. With dividing head at 30°, adjust the Phase Angle Dial on the voltmeter for a quadrature null.

4. The phase shift of the CX may be read directly from the Phase Angle Dial.

E. Input Current Test

1. Set up circuit indicated.

2. Turn voltmeter Function Selector to the Total position.

3. The input current of the CX is read directly in amperes on the voltmeter, i.e., .1 volt = .1 amperes.

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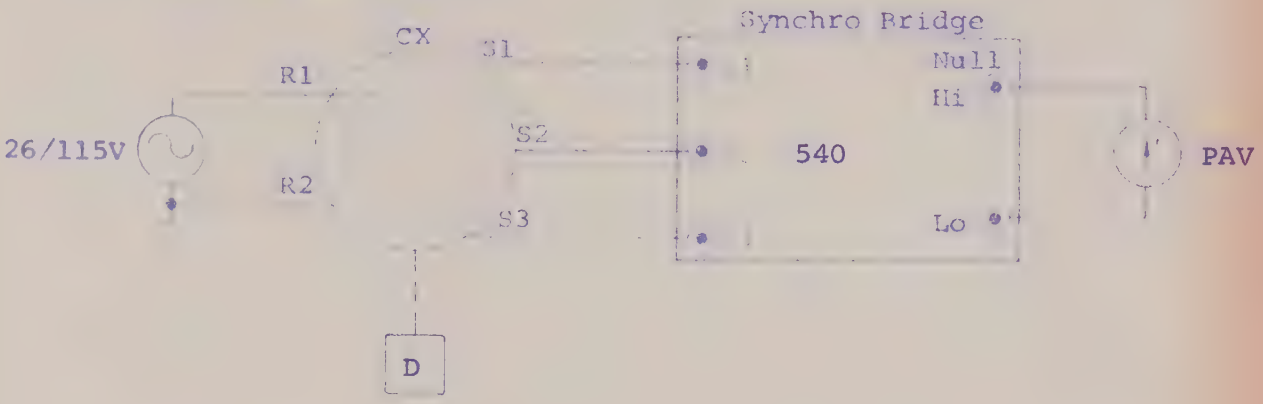
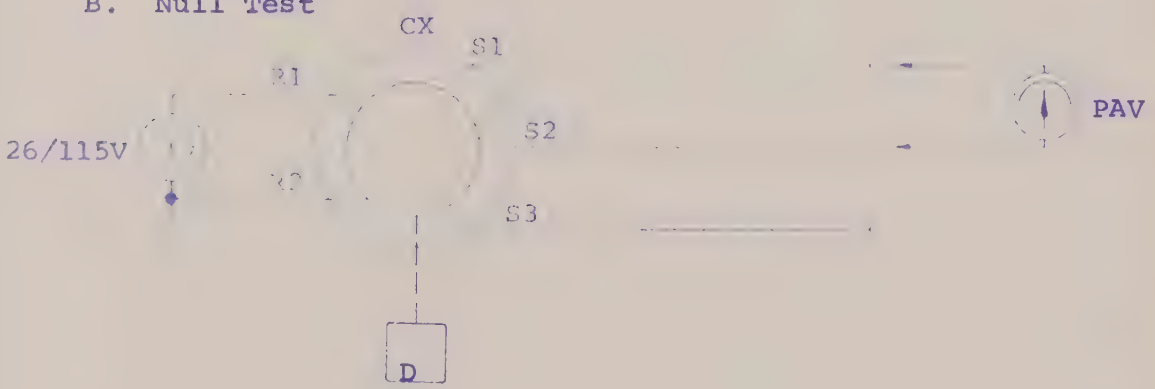
TEST CIRCUIT SCHEMATICS

I. Synchro Transmitter (CX)

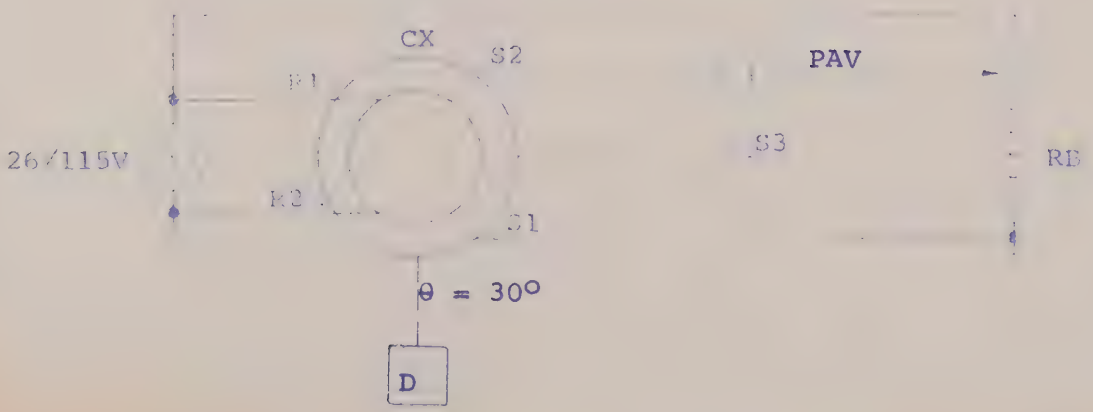
A. Angular Accuracy



B. Null Test



C. Transformation Ratio Test



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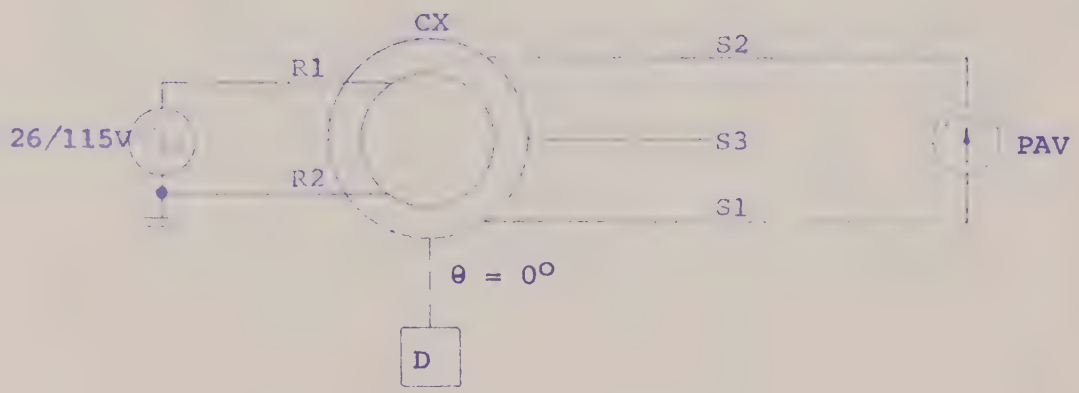
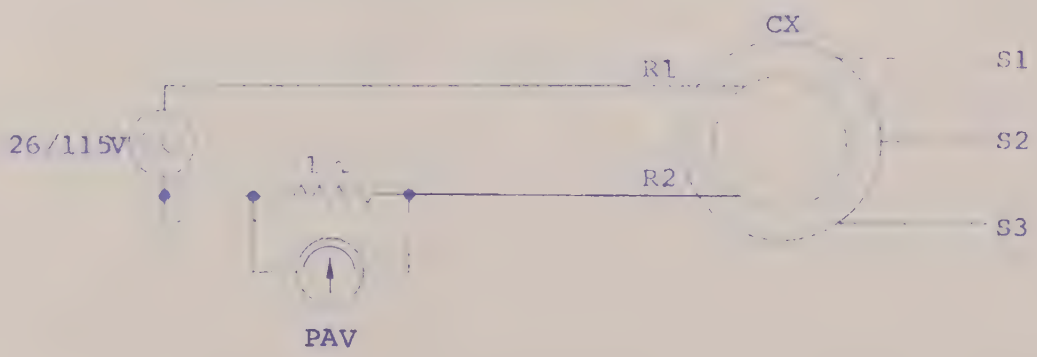
D. Phase Shift Test



E. Input Current Test



II. Synchro Differential Transmitter (CDX) Test

A. Phasing, Electrical Zero, and Angular Accuracy Test

1. Set up circuit A-1 as indicated.

2. Set 530 and 540 to 0°.

3. Rotate CDX shaft counterclockwise, as viewed from the shaft end, until the meter reads zero. Note that the needle approaches zero from left to right. For 115V excitation, use 100V range of the voltmeter. For 26V excitation, use 30V range of the voltmeter.

4. With synchro shaft at null, switch the 540 to 5°. The voltmeter should deflect to the left. Return to 0°.

5. Switch 530 to 5°. The voltmeter should deflect to the left. Return the 530 to 0°.

6. If the requirements of Steps 3, 4, and 5 are met, the phasing is correct, and the null point is electrical zero.

7. Mount CDX in the dividing head.

8. With the dividing head at 0, CDX must be at electrical zero, as defined by Steps 3 - 5.

9. Set voltmeter Function Selector to 90°.

10. Set 540 to 90°.

11. Rotate the Phase Angle Dial until quadrature null is reached.

12. The angle read on the Phase Angle Dial is approximately equal to the phase shift of the CDX.

13. With the Phase Angle Dial left at this setting, return the 540 and the Function Selector to 0^{o}.

14. Re-zero CDX in the dividing head if necessary.

15. With the CDX at zero, offset dividing head by an amount equal to the maximum allowable error of the CDX.

16. Down scale the Range Selector until the first off scale meter reading is reached. Turn the Range Selector to the next up-scale range. Record the deflection noted on the PAV. This is the maximum allowable error voltage.

17. Return dividing head to 0^{o}.

18. Advance the 530 and the dividing in the required increments. The null as noted on the PAV should be less than that obtained in Step 16.

19. Set up circuit A-2 indicated with CDX still mounted in the dividing head.

20. Check that CDX is zero and dividing head is set to zero.

21. Advance the 530 and the dividing head in the required increments. The null error as noted on the PAV should be less than that obtained in Step 16.

B. Null Test, Fundamental and Total

1. Set up circuit as indicated.
2. Attach PAV leads to R1 and R2.
3. Set 530 to 120° and dividing head to 0°.
4. Set voltmeter Function Selector to 0° and adjust dividing head vernier for a null.
5. In the Total and Fundamental positions of the Function Selector, read the respective nulls.
6. Set 530 to 240° and dividing head to 120°.
7. Repeat Steps 4 and 5.
8. Set 530 to 0° and dividing head to 240°.
9. Repeat Steps 4 and 5.
10. Attach PAV leads to R2 and R3.
11. Set 530 to 240° and dividing head to 0°.
12. Repeat Steps 4 and 5.
13. Set 530 to 0° and dividing head to 120°.
14. Repeat Steps 4 and 5.
15. Set 530 to 120° and dividing head to 240°.
16. Repeat Steps 4 and 5.
17. Attach PAV leads to R1 and R3.
18. Set 530 to 120° and dividing head to 0°.
19. Repeat Steps 4 and 5.

20. Set 530 and dividing head to 120°, and repeat Steps 4 and 5.

21. Set 530 and dividing head to 240°, and repeat Steps 4 and 5.

C. Transformation Ratio Test

1. Set up circuit indicated.

2. Set Phase Angle Dial to 0°.

3. Set dividing head to 30°.

4. Switch voltmeter Function Selector to 0°.

5. Set Ratio Box for a null on the voltmeter.

6. Record ratio reading.

7. Transformation ratio is obtained by dividing in-phase ratio by cos 30° (.866).

D. Phase Shift Test

1. Set up circuit indicated.

2. Set Function Selector to 90°.

3. Set dividing head to 30°, and rotate Phase Angle Dial for quadrature null.

4. The phase shift of the CDX may be read directly from the Phase Angle Dial.

E. Input Current Test

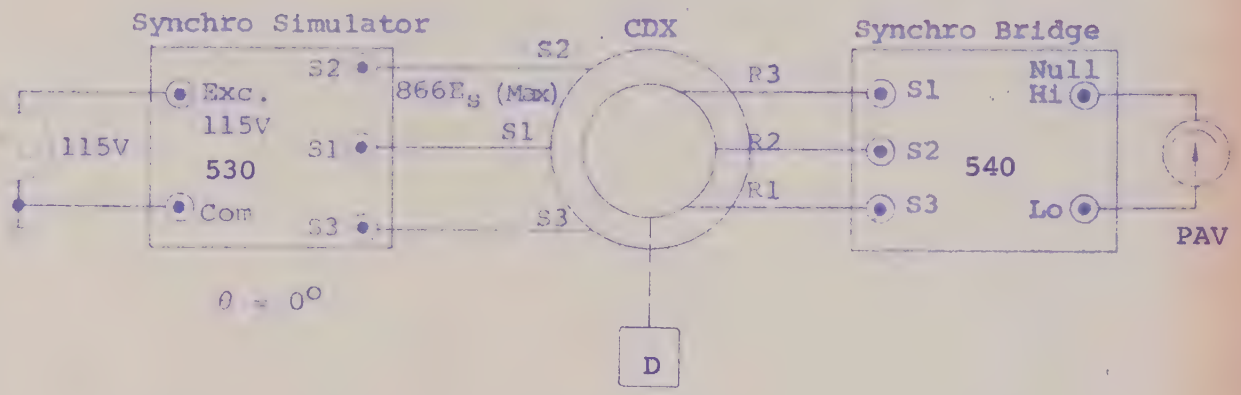
1. Set up circuit indicated.

2. Switch voltmeter Function Selector to Total.

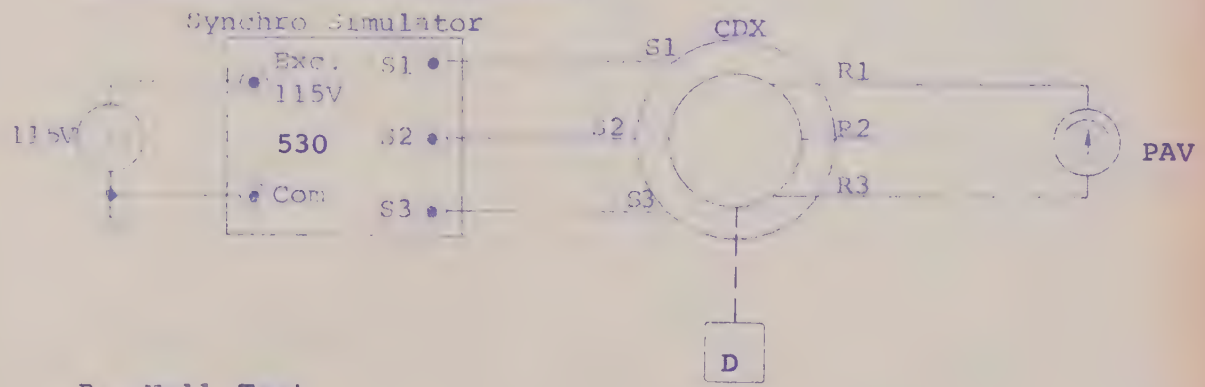
3. The input current of the CDX is read directly in amperes on the voltmeter, i.e., .1 volts = .1 amperes.

II. Synchro Differential Transmitters (CDX)

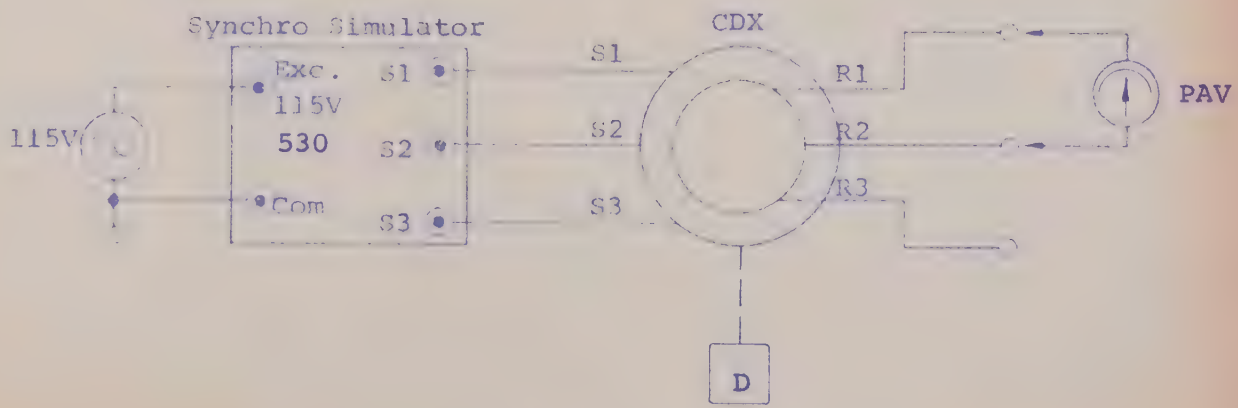
A1 Angular Accuracy (Rotor)



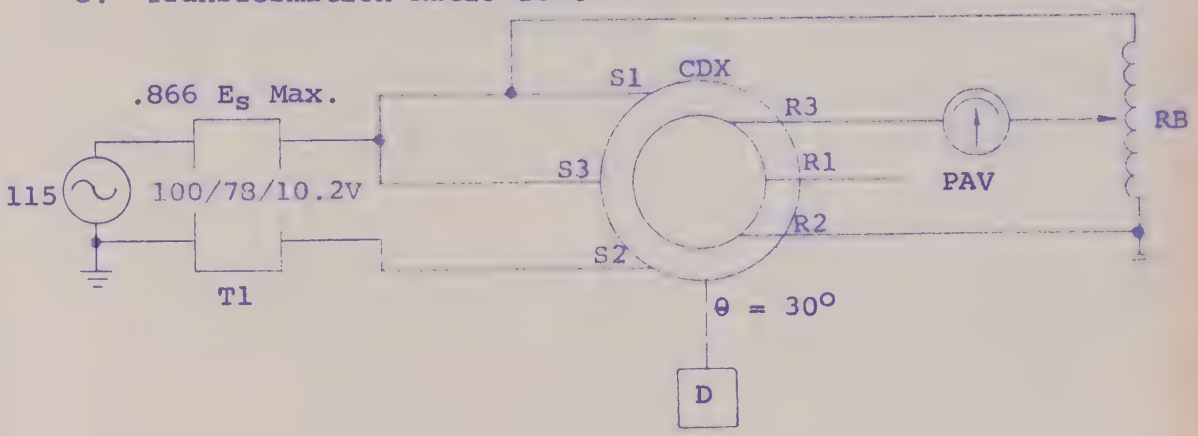
A2 Angular Accuracy (Stator)



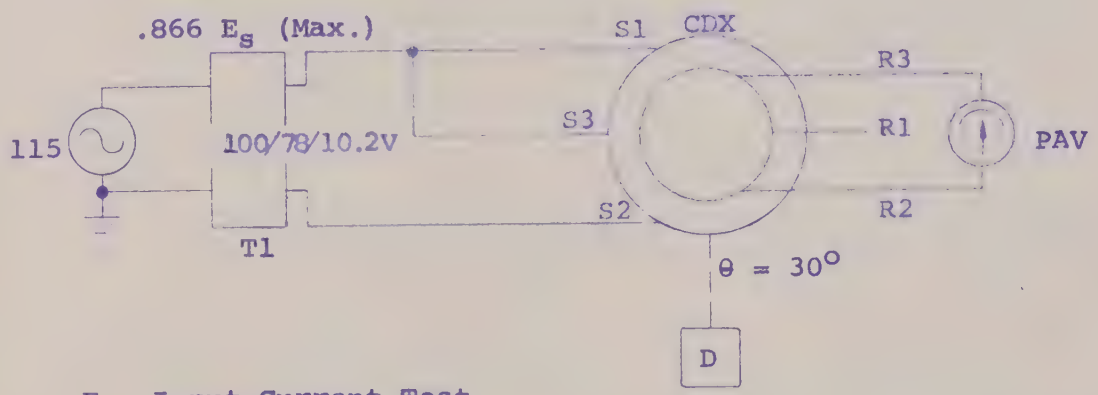
B. Null Test



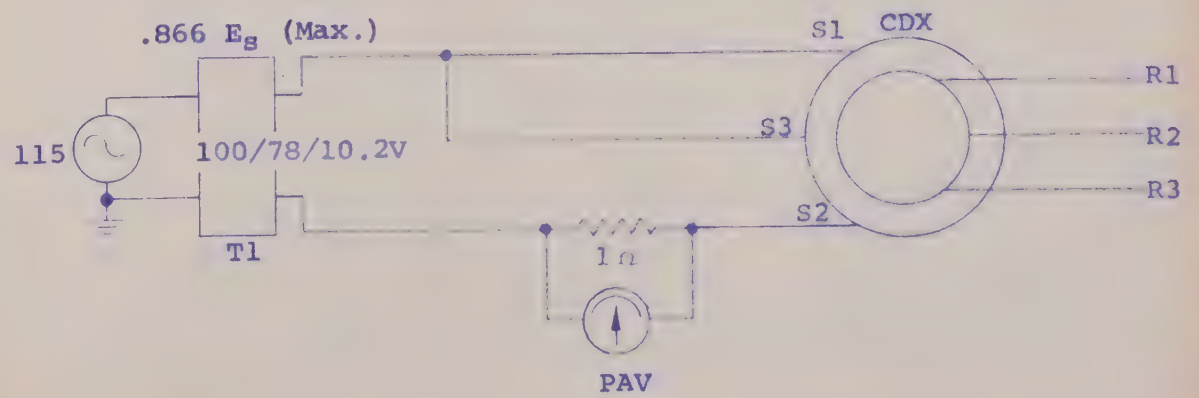
C. Transformation Ratio Test



D. Phase Shift Test



E. Input Current Test



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III. Synchro Transformer (CT) Test

A. Phasing, Electrical Zero, and Angular Accuracy

1. Set up circuit indicated.

2. Set 530 to 0°.

3. Rotate CT shaft counterclockwise, as viewed from the shaft end, until the meter reads zero. Note that the needle approaches zero from left to right. For 115V or 90V excitation, use the 100V range of the voltmeter. For 11.8V excitation, use the 10V range of the voltmeter.

4. With synchro shaft at the null point, switch 530 to 5°. The voltmeter should deflect to the left.

5. Return the 530 to 0°.

6. If the requirements of Steps 3 and 4 are met, the phasing is correct, and the null point is electrical zero.

7. Mount the CT in the dividing head.

8. With the dividing head at 0°, CT must be at electrical zero, as defined in Test 3 and 4.

9. Set voltmeter Function Selector to 90°.

10. Set 530 to 90°.

11. Rotate the Phase Angle Dial until quadrature null is reached.

12. With Phase Angle Dial left at this setting, return the 530 to 0°, and set the Function Selector to 0°.

13. Re-zero CT in the dividing head if necessary.

14. With CT at zero, offset dividing head by an amount equal to the maximum allowable error of the CT.

15. Down scale the Range Selector until the off-scale meter reading is reached. Turn the Range Selector to the next up-scale range. Record the deflection noted on the PAV. This is the maximum allowable error voltage.

16. Return the dividing head to 0°.

17. Advance the 530 and the dividing head in the required increments. The null error as noted on the PAV should be less than that obtained in Step 15.

B. Null Test, Fundamental and Total

1. Set up circuit as indicated.

2. Set 530 and dividing head to 0°.

3. Set the voltmeter Function Selector to 0°, and adjust dividing head vernier for a null.

4. Read the null in the Total and Fundamental positions of the Function Selector.

C. Transformation Ratio Test

1. Set up circuit as indicated.

2. Turn Phase Angle Dial to 0°.

3. Set dividing head to 270°.

4. Set voltmeter Function Selector to 0°.

5. Adjust Ratio Box for a null on the meter.

6. Record Ratio Box reading.

7. Transformation ratio is obtained by dividing in-phase ratio by cos 30° (.866).

D. Phase Shift Test

1. Set up circuit indicated.

2. Set voltmeter Function Selector to 90°.

3. With dividing head at 270°, rotate Phase Angle Dial on the voltmeter for a null.

4. The phase shift of the CT may be read directly from the Phase Angle Dial.

E. Input Current Test

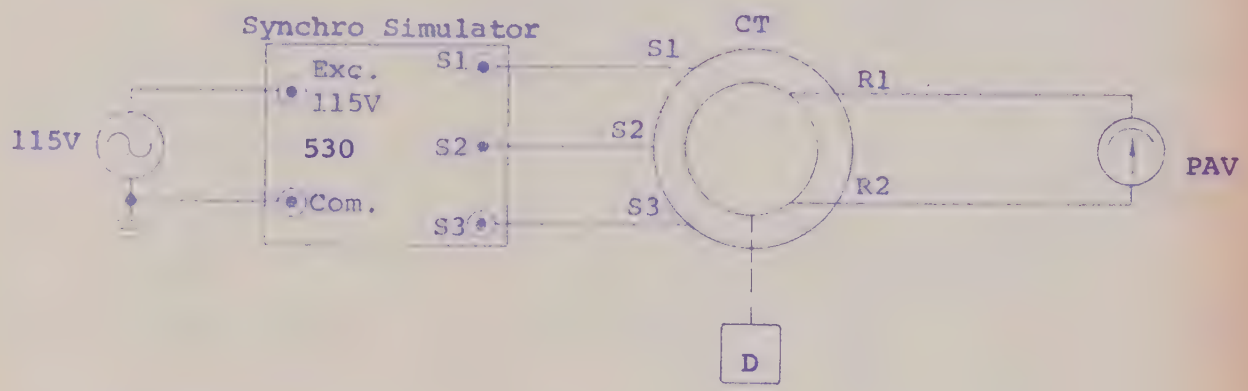
1. Set up circuit as indicated.

2. Set voltmeter Function Selector to Total.

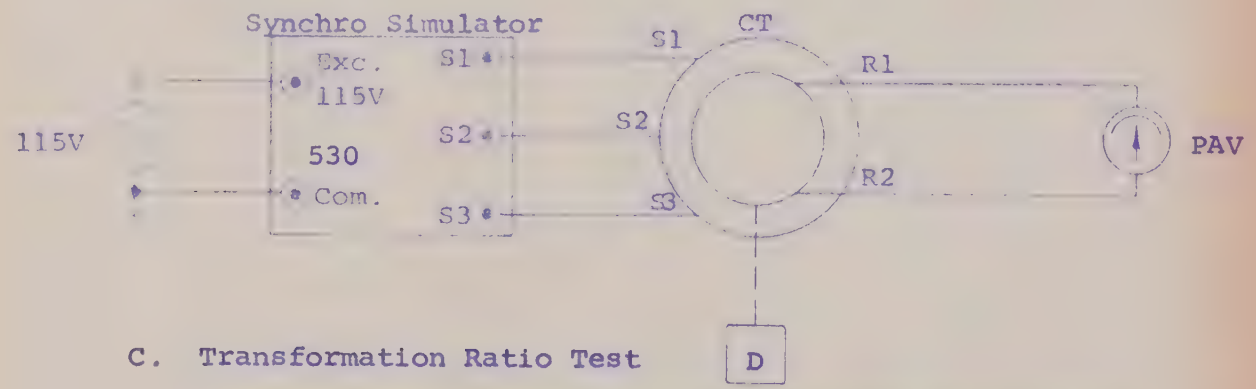
3. The input current of the CT is read directly in amperes on the voltmeter, i.e., .1V = .1 amperes.

III. Synchro Transformer (CT)

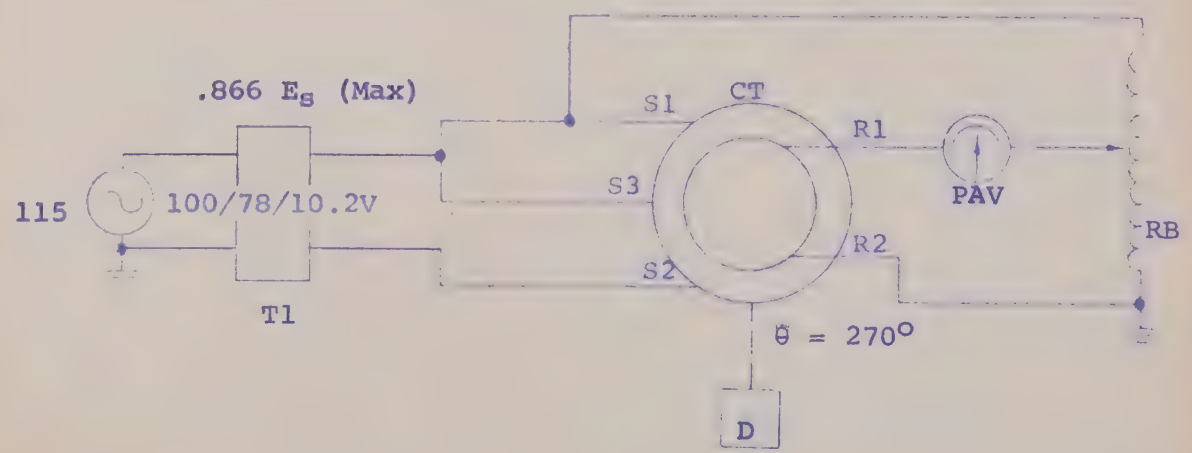
A. Angular Accuracy



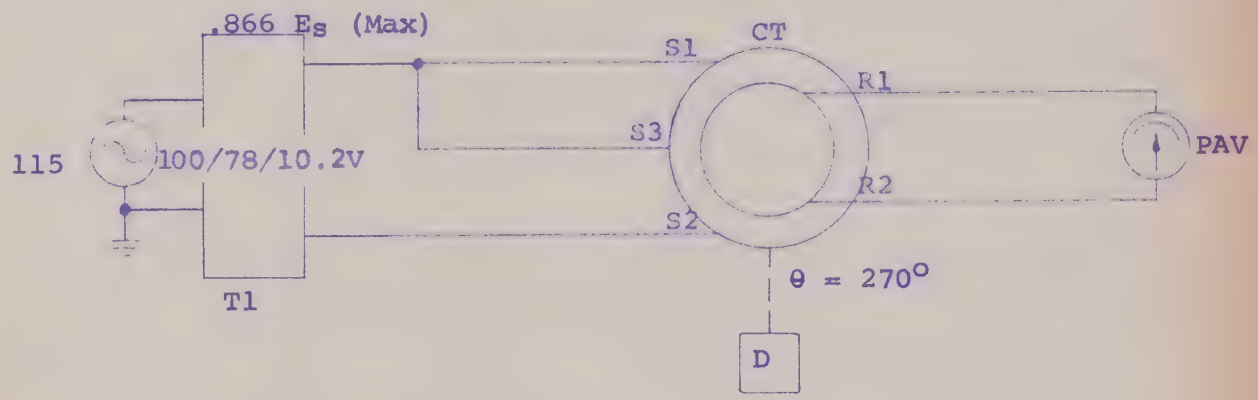
B. Null Test



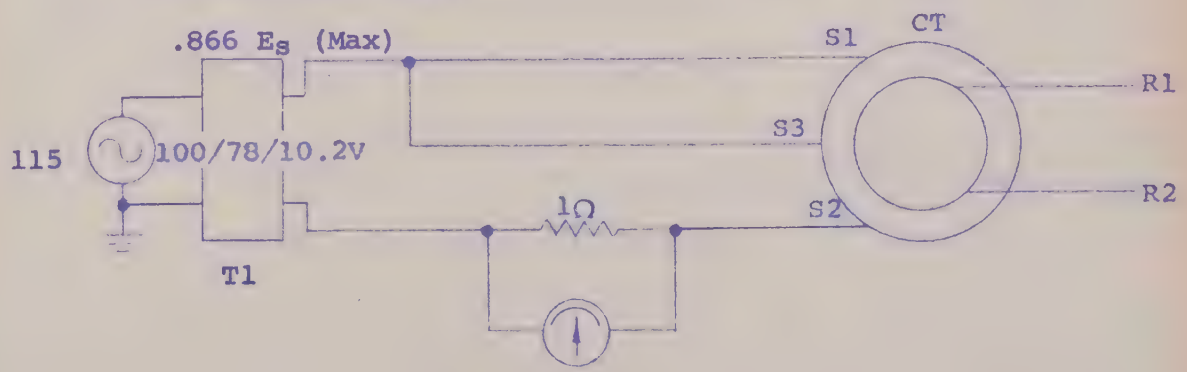
C. Transformation Ratio Test



D. Phase Shift Test



E. Input Current Test



IV. Resolver Transmitter (RX)

A. Phasing, Electrical Zero, and Angular Accuracy

1. Set up circuit indicated.
2. Set 540 to 0°.
3. Rotate RX shaft counterclockwise, as viewed from the shaft end, until meter reads zero. Note that the needle approaches zero from right to left.
4. For 115V excitation, use 100 volt range of the voltmeter. For 26V excitation, use 30 volt range of the voltmeter.
5. With resolver shaft at the null point, switch 540 to 5°.
6. Return the 530 to 0°.
7. If the requirements of Steps 3 and 5 are met, the phasing is correct, and the null point is electrical zero.
8. Mount RX in a dividing head.
9. With the dividing head at 0°, RX must be at electrical zero as described in Steps 3 and 5.
10. Set voltmeter Function Selector to 90°.
11. Set 540 to 90°.
12. Rotate Phase Angle Dial until quadrature null is reached.

13. The angle read on the Phase Angle Dial is approximately equal to the phase shift of the RX.

14. With the Phase Angle Dial left at this setting, return the 540 and the Function Selector to 0^{o}.

15. Re-zero the CX and the dividing head if necessary.

16. With RX at zero, offset the dividing head by the maximum allowable error.

17. Down-scale the Range Selector until the first off-scale meter reading is reached. Turn the Range Selector to the next up scale range. Record the deflection noted on the PAV. This is the maximum allowable error voltage.

18. Return the dividing head to 0^{o}.

19. Advance 540 and the dividing head in the required increments. The null error as noted on the PAV should be less than that obtained in Step 17.

B. Null Test, Fundamental and Total

1. Set up circuit indicated.

2. Set the dividing head to 0^{o}.

3. Set Function Selector to 0^{o}, and adjust dividing head vernier for a null.

4. Read null in Total and Fundamental positions of the Function Selector.

5. Attach the voltmeter leads to S2 and S4 and rotate dividing head to 90^{o}.

6. Repeat Steps 3 and 4.

C. Transformation Ratio Tests

1. Set up circuit indicated.

2. Turn voltmeter Phase Angle Dial to 0^{o}.

3. Turn voltmeter Function Selector to 0^{o}.

4. Set dividing head to 0^{o}, and adjust Ratio Box for a null.

5. Record ratio reading (transformation ratio).

D. Phase Shift Test

1. Set up circuit as indicated.

2. Set voltmeter Function Selector to Total.

3. The input current of the RX is read directly in amperes on the voltmeter, i.e., .1 volts = .1 amperes.

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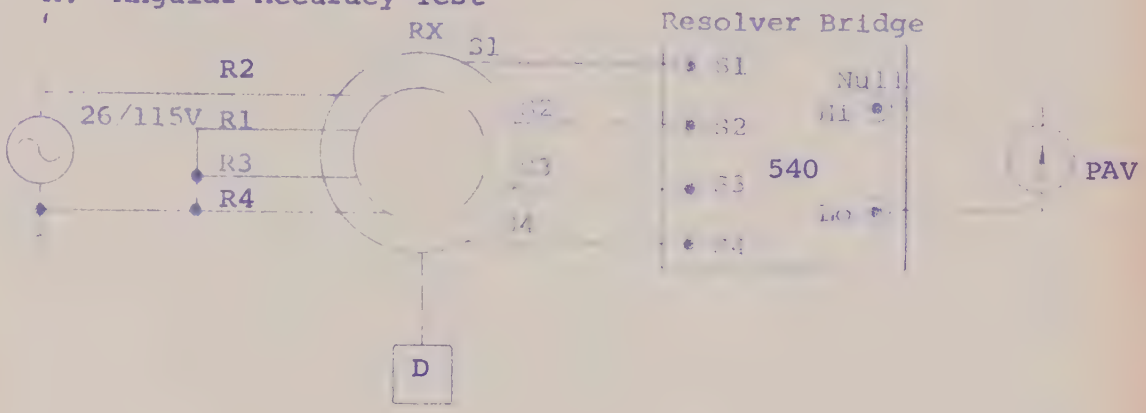
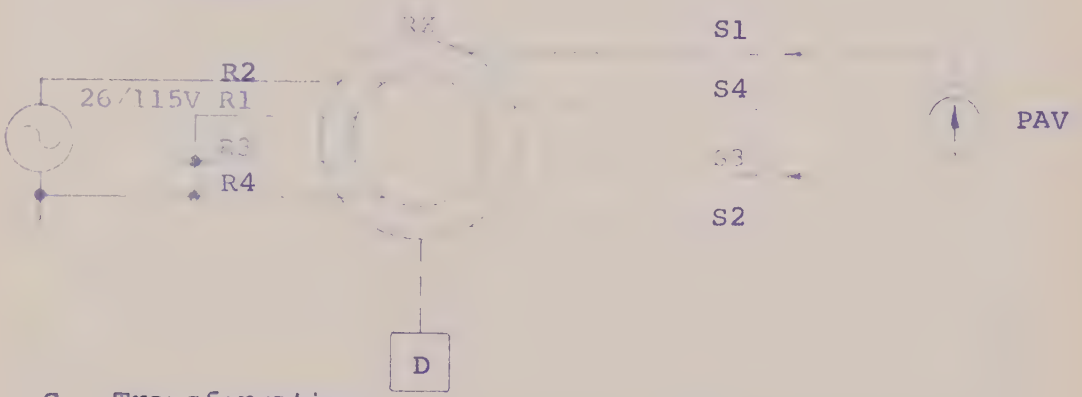
IV. Resolver Transmitter (RX)

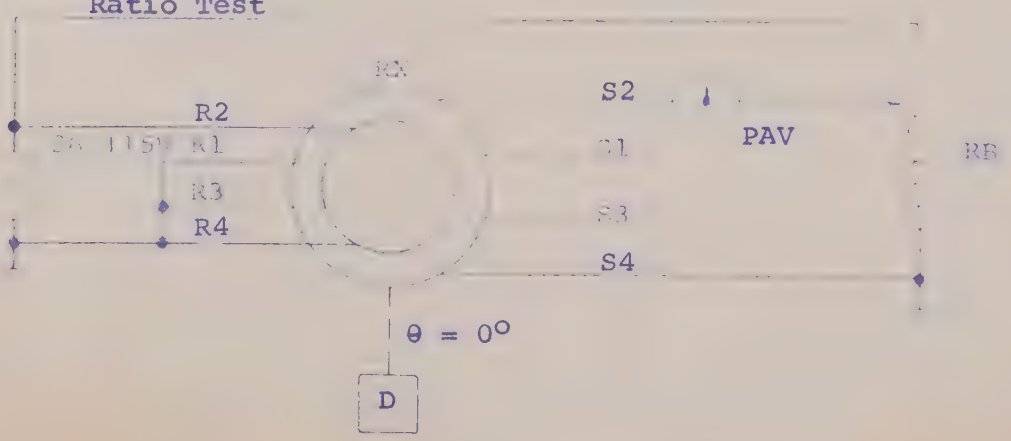
A. Angular Accuracy Test



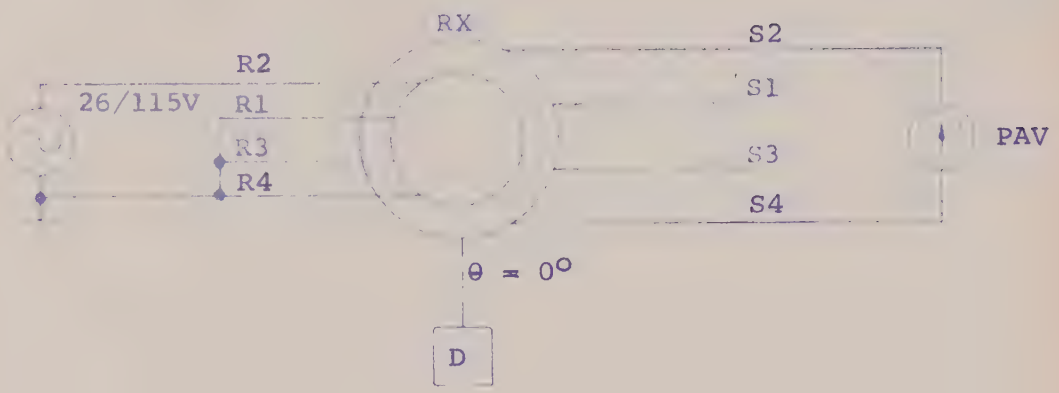
B. Null Test



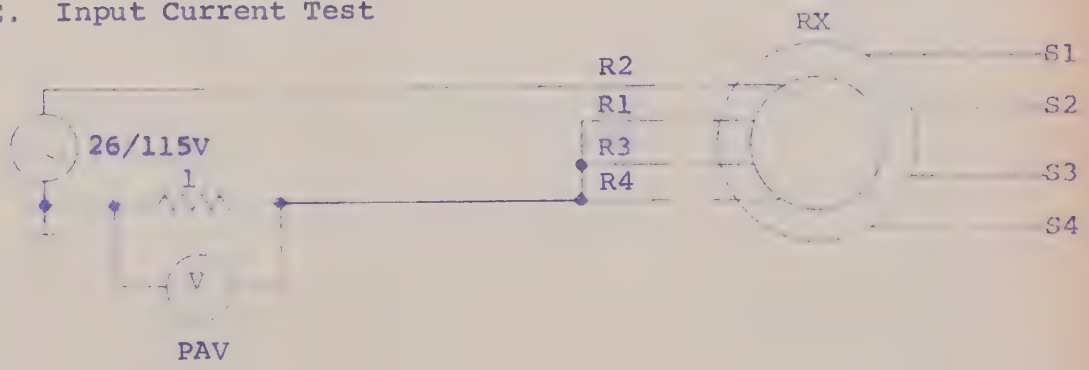
C. Transformation Ratio Test



D. Phase Shift Test



E. Input Current Test



V. Differential Resolver and Transformer (RD/RC) Tests

A. Phasing, Electrical Zero, and Angular Accuracy

1. Set up circuit A-1 as indicated.

2. Set the 530 and 540 to 0°.

3. Turn control panel power on, and rotate RD/RC shaft counterclockwise as viewed from the shaft end until the meter reads 0. Note that the needle approaches zero from left to right. For 115V excitation, use 100V range of the voltmeter. For 11.8V excitation, use 10V range of the voltmeter.

4. With RD/RC shaft at null point, switch 540 to 5°.

5. The voltmeter should deflect to the left. Return 540 to 0°.

6. Switch 530 to 5°. The meter should deflect to the left.

7. Return 530 to 0°.

8. If the requirements of Steps 3 - 6 are met, phasing is correct, and the null point is electrical zero.

9. Mount RD/RC in a dividing head.

10. With the dividing head at 0, RD/RC must be at electrical zero as described in Steps 3-6.

11. Set 530 to 90°.

12. Set voltmeter Function Selector to 90°.

13. Rotate Phase Angle Dial until quadrature null is reached.

14. The angle read on the Phase Angle Dial is approximately equal to the phase shift of the RD/RC.

15. Re-zero the RD/RC in the dividing head if necessary.

16. With the RD/RC at zero, offset the dividing head by an amount equal to the maximum allowable error of the RD/RC.

17. Down scale the Range Selector until the first off scale meter reading is reached. Turn the Range Selector to the next up-scale range. Record the deflection noted on the PAV. This is the maximum allowable error voltage.

18. Return the dividing head to 0^{o}.

19. Advance 540 and the dividing head the required increments. The null error as noted on the PAV should be less than that obtained in Step 17.

20. Set up circuit A-2 as indicated.

21. Re-zero the RD in the dividing head if necessary.

22. Advance 530 and the dividing head in the required increments. The null error as noted on the PAV should be less than that obtained in Step 17.

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B. Null Test, Fundamental and Total

1. Set up circuit indicated.
2. Set 530 and dividing head to 0°.
3. Set the Function Selector to 0°, and adjust the dividing head vernier for a null.
4. Read the null in both Total and Fundamental positions of the Function Selector.
5. Set 530 and dividing head to 90°.
6. Repeat Steps 3 and 4.
7. Attach voltmeter leads to R2 and R4.
8. Set 530 to 90° and dividing head to 0°.
9. Repeat Steps 3 and 4.
10. Set 530 to 0° and dividing head to 90°.
11. Repeat Steps 3 and 4.

C. Transformation Ratio Test

1. Set up circuit indicated.
2. Turn Phase Angle Dial to 0°.
3. Turn voltmeter Function Selector to 0°.
4. Set dividing head to 0°.
5. Adjust Ratio Box for a null on the voltmeter.

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6. Record Ratio Box reading (transformation ratio).

D. Phase Shift Test

1. Set up circuit indicated.

2. Set voltmeter Function Selector to 90^{o}.

3. With the dividing head at 0^{o}, rotate the Phase Angle Dial on the voltmeter for a null.

4. The phase shift of the RD/RC may be read directly from the Phase Angle Dial.

E. Input Current Test

1. Set up circuit indicated.

2. Set voltmeter Function Selector to Total.

3. The input current of the RD/RC is read directly in amperes on the voltmeter, i.e., .1 volt = .1 amperes.

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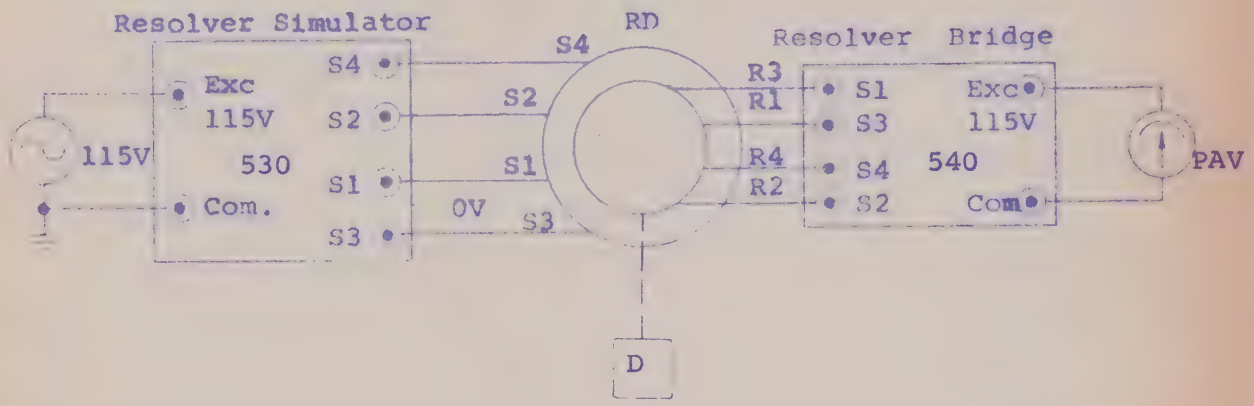
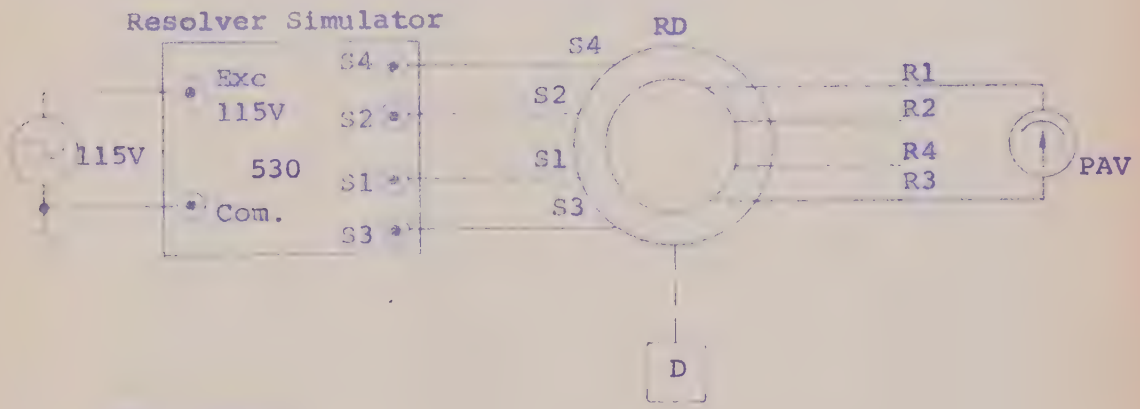
V. Resolver Differential Transmitter or Transformer (RD/RC)

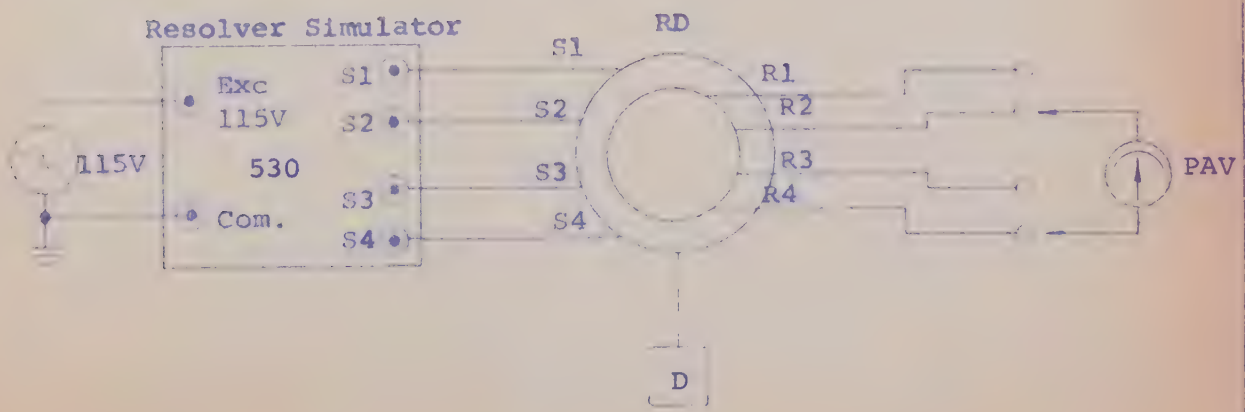
A1. Angular Accuracy (RD Rotor)



A2. Angular Accuracy (RD and RC Stator)



B. Null Test



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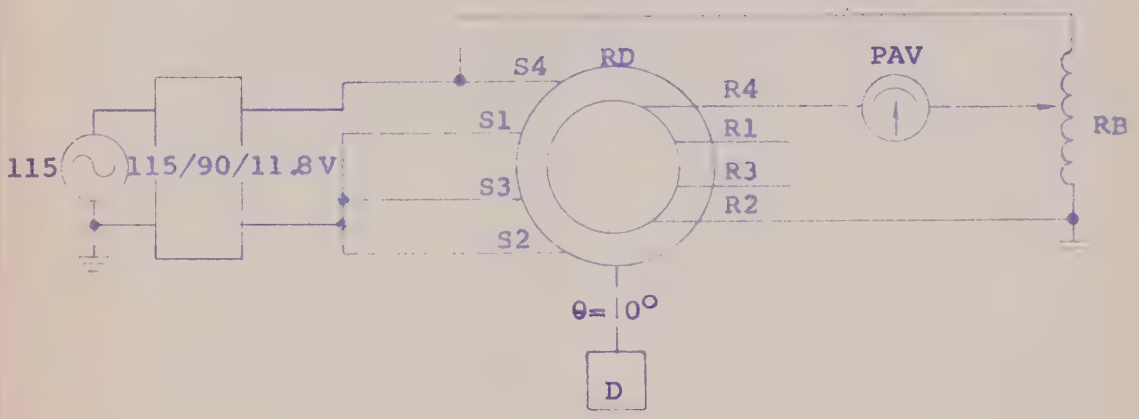
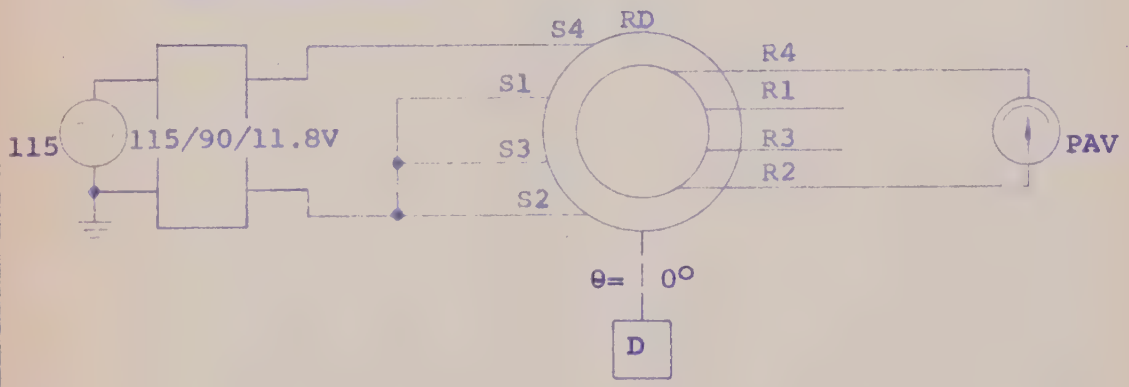
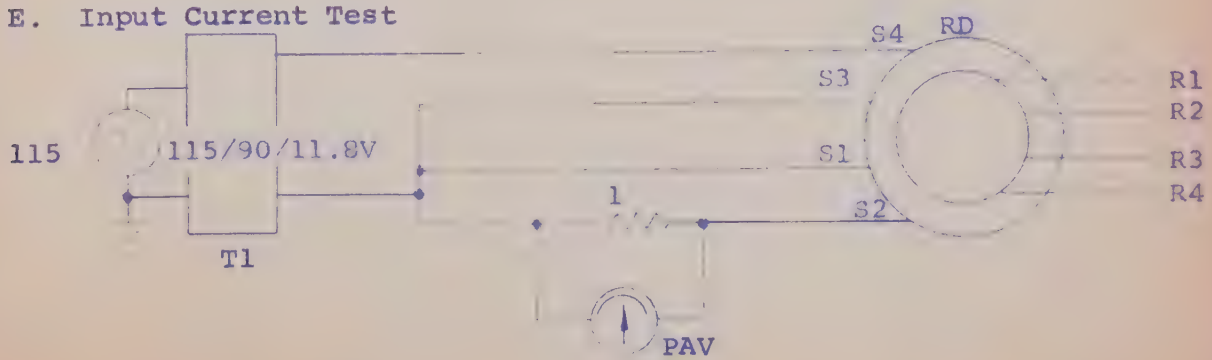
C. Transformation Ratio Test



D. Phase Shift Test



E. Input Current Test



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SECTION IX

REPLACEMENT PARTS LIST

REPLACEMENT PARTS LIST

Resolver-Synchro Simulator
1°, Full Rack

Model 531-S1038

Designation	Description	NAI Part No.	Manufacturer
T1	Transformer, Section A Assembly	782394	
S18	Switch Assembly, 10°	C-782159	
S1	Switch Assembly, 1°	C-782200	
S6,S7	Switch, Concentric (Mode)Modified	C-201965	
	Fuseholder	802387	Bussman #HWA
	Knob, Fuseholder	802535	Bussman #AF
	Fuse, 2 amp.	802893	Bussman GMW-2AMP
	Fuse, 5 amp.	802728	Bussman GMW-5AMP
	Dial Assembly, 100°	500395-1	
	Dial, 10°	201955	
	Dial Assembly, 1°	500395-2	
	Binding Post, Gnd.	800546	H.H.Smith #137
	Binding Post, Red	800119	Grayhill#29-1R
	Binding Post, Black	800120	Grayhill#29-1B
	Knob, Bar	201979	
	Knob, Concentric, Inside	201719-1	
	Knob, Concentric, Outside	201946-1	

* Mfg. and part number (or equal) may be used. When no number is shown special NAI parts must be used as indicated.

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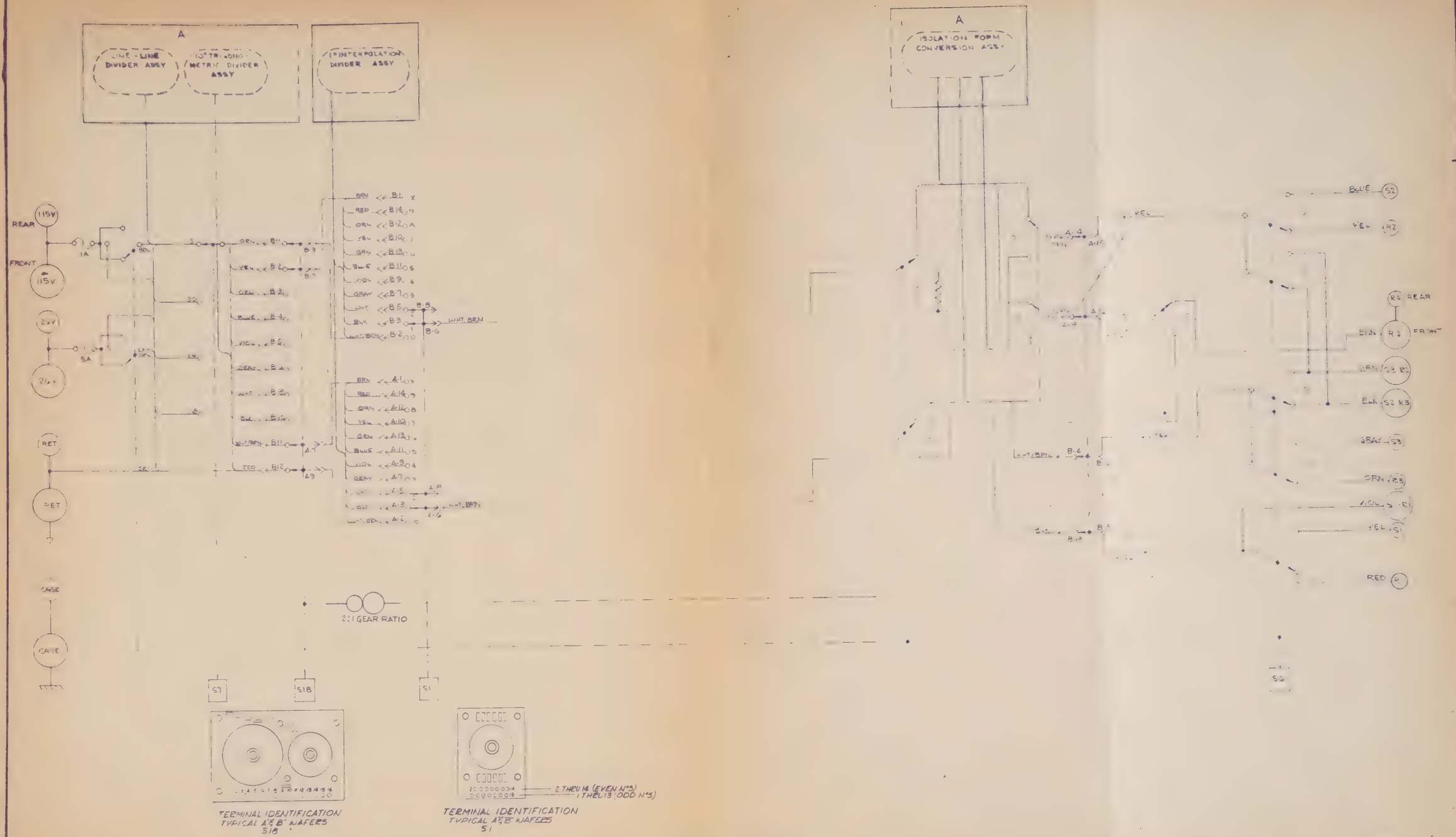
SECTION X

SCHEMATICS



1° RES./SYN. SIMULATOR
SCHEMATIC # 100376

405329

CAUTION

High voltage exists at several points in the instrument. Normal precautions consistent with good practice should be taken to reduce shock hazard.

A potential shock hazard exists when ungrounded power source or ungrounded case operation is employed. Persons operating the instrument should be made aware of and take precautions against this condition.

North Atlantic Industries, Inc. cannot be held responsible for damage to person or property in the process of or as a result of maintenance, calibration, or setting up of the instrument.

WARRANTY

North Atlantic Industries, Inc. warrants its products against defects in material and workmanship for one year from the date of the original shipment. Our liability is limited to repairing or replacing products (except fuses and electron tubes) which prove to be defective during the warranty period.

North Atlantic Industries, Inc. is not liable for consequential damages or for any damage or injury to persons or property resulting from the operation or application of any of its equipment.

Warranty is voided if there is evidence that the product has been operated beyond its design range, improperly maintained, or physically mistreated.

In the event of a malfunction in a product under warranty, the purchaser should notify his local Sales Representative or the Sales Department of North Atlantic Industries, Inc. giving full details of the defect and providing the model and serial number of the instrument. Service data or shipping instructions will be forwarded promptly. There is no charge for warranty repair of products, except transportation charges.

North Atlantic Industries, Inc. reserves the right to make changes and improvements in its products without any liability for incorporating such changes or improvements in any products previously sold.

No other warranty expressed or implied is offered other than the foregoing.

Estimates of charges for out of warranty repairs or other service work will be supplied before work begins. Out of warranty repairs will only be made following the receipt of purchaser's authorization of applicable charges.

Claims for Damage in Shipment

The purchaser should inspect and functionally test the product in accordance with the instruction manual as soon as it is received. If the product is damaged in any way, including concealed damage, a claim should be filed immediately with the carrier, or, if insured separately, with the purchaser's insurance company.

(turn over for Shipping Instructions)

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Shipping

On products to be returned under warranty, await receipt of shipping instructions, then forward the instrument prepaid to the destination indicated. The original shipping containers with their appropriate blocking and isolating material is the preferred method of packaging. Any other suitably strong container may be used providing the product is wrapped in heavy paper or a plastic bag and surrounded with at least four inches of shock absorbing material to cushion firmly, preventing movement inside the container.

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WARRANTY REGISTRATION

Please complete and mail this Warranty Registration Card without delay. Placing this Registration on file with our Service Department will assure that you receive applicable service data as issued. No postage is required. (Mailed on_____ by_____)

WARRANTY REGISTRATION

Date _____

Please register _____

Model No. _____ Serial No. _____

under the terms of the warranty stated in this Instruction Manual.

Name _____

Title _____ Dept. _____

Company _____

Address _____

City _____ State _____ ZIP _____

Calibration and maintenance responsibility has been assigned to the following person and/or department. Address applicable service data to (if same as above, please state):

Name _____

Title _____ Dept. _____

For our information please indicate:

Condition of instrument on receipt _____

Application _____

Will the instrument be: resold as part of a system? _____

maintained as company equipment? _____

SERVICE INFORMATION

This card is provided to aid you in obtaining prompt assistance with questions you may have regarding operation, calibration, maintenance or service parts for your North Atlantic instrument. State information desired and mail. No postage is required.

SERVICE INFORMATION REQUEST

Instrument _____

Model No. _____ Serial No. _____

We require the following service information: _____

_____

_____

_____

_____

Name _____ Title _____

Company _____ Dept. _____

Address _____

City _____ State _____ ZIP _____

Phone _____ Ext. _____

SERVICE INFORMATION

This card is provided to aid you in obtaining prompt assistance with questions you may have regarding operation, calibration, maintenance or service parts for your North Atlantic instrument. State information desired and mail. No postage is required.

SERVICE INFORMATION REQUEST

Instrument _____

Model No. _____ Serial No. _____

We require the following service information: _____

_____

_____

_____

_____

Name _____ Title _____

Company _____ Dept. _____

Address _____

City _____ State _____ ZIP _____

Phone _____ Ext. _____

(please send additional Service Information Request cards_____)

No Postage Stamp Necessary If Mailed in the United States

Postage Will be Paid by Addressee

BUSINESS REPLY MAIL

First Class Permit No. 505, Sec. 34.9, P.L.&R. Hicksville, L. I., N. Y.

NORTH ATLANTIC
industries, inc.

200 TERMINAL DRIVE,

PLAINVIEW, N. Y. 11803

No Postage Stamp Necessary If Mailed in the United States

Postage Will be Paid by Addressee

BUSINESS REPLY MAIL

First Class Permit No. 505, Sec. 34.9, P.L.&R. Hicksville, L. I., N. Y.

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PLAINVIEW, N. Y. 11803

NORTH ATLANTIC

PHASE ANGLE VOLTMETER

MODEL VM-202

FEATURES

- Direct Reading Of
  - Phase Angle
  - Total Voltage
  - In-phase Voltage
  - Quadrature Voltage
  - Nulls
- Filters To Reduce Harmonic Effects
- Excellent Quadrature Rejection
- High Sensitivity For Accurate Nulling And Low Level Measurement

DESCRIPTION

The Model VM-202 Phase Angle Voltmeter combines in one compact instrument all the functions necessary for precise measurement of magnitude and phase characteristics of complex a-c signals and their component voltages.

Designed to meet laboratory, production line and ground checkout requirements, the instrument includes the functions of (1) a sensitive vacuum tube voltmeter, (2) a phase angle meter, (3) a meter measuring in-phase and quadrature signals, (4) a phase-sensitive null detector, (5) an impedance meter and (6) a power factor meter. Voltages, phase angles and nulls are read directly, without the need for accessory equipment. An integral, calibrated phase shifter, adjusted at the front panel, provides direct reading of phase angle with respect to a reference from 0 to 360 degrees without ambiguity.

Inherent instrument characteristics reject all even harmonics. Integral selective filters attenuate odd harmonics. Exceptionally accurate null indications, such as required for precise measurement of a-c voltage ratios, are assured by the instrument's high sensitivity, low internal noise and phase sensitive characteristics. For applications where it is desired to isolate the reference signal or accommodate balanced inputs, or for use of the VM-202 in a-c ratiometry, the instrument includes provision for front panel plug-in of isolation, summing and bridging transformer modules, available as optional accessories.

The Model VM-202 Phase Angle Voltmeter can be supplied to accommodate signals at any pre-specified frequency within the range 30 cps to 10 k c. Operating principles and circuit design are shown in the functional schematic on the reverse side of this bulletin.

TYPICAL APPLICATIONS

The ability of the VM-202 Phase Angle Voltmeter to measure both magnitude and phase angle of signal components makes it especially valuable for circuit development and for production and field testing of servos, resolvers, computers and similar a-c devices and systems. Other typical applications include:

- Phase sensitive null indication for precise a-c ratio measurement
- Zeroing of high-precision synchros and resolvers
- Phasing of two-phase servo motors and amplifiers
- Trimming and zeroing of transducers and sensors
- Alignment of carrier amplifiers and notch networks
- Phase alignment of magnetic amplifier systems, including measurement of both torque- and non-torque-producing signals

Three Frequency Model 204 also available. Write for Bulletin VM-204. Detailed application notes on the VM-202 and other Series 200 Phase Angle Voltmeters are available on request.

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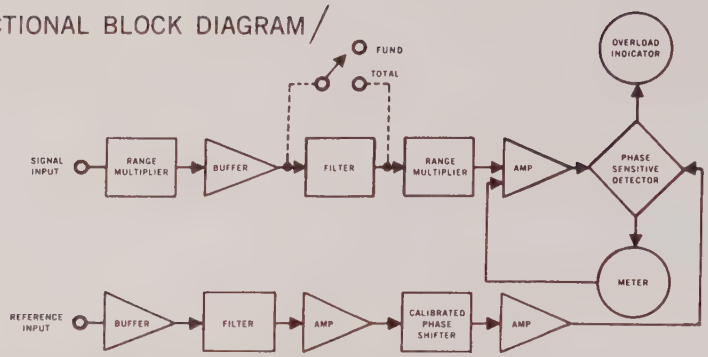
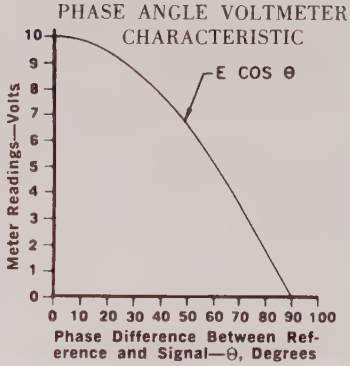
FUNCTIONAL BLOCK DIAGRAM /



PHASE ANGLE VOLTMETER CHARACTERISTIC


E COS Θ
Meter Readings—Volts
0 1 2 3 4 5 6 7 8 9 10
0 10 20 30 40 50 60 70 80 90 100
Phase Difference Between Reference and Signal—Θ, Degrees

SPECIFICATIONS /

GENERAL	models covered by this specification are single frequency instruments in the range 30 cps to 10 kc. Model VM-202BR includes filters in both signal and reference channels. Model VM-202AR (with filters in signal channel only) and Model VM-202R (without filters) are also available. The letter T after the part number (for example, VM-202BRT) indicates the inclusion of a built-in reference isolation transformer.
VOLTAGE RANGE	1.0 millivolt to 300 volts full scale, in 12 ranges. Higher sensitivities on request.
ACCURACY	±2% of full scale voltage range. ±3% of full scale degrees as a phase angle meter using E cos Θ characteristic, for up to 5:1 full scale overload. ±1.0° phase angle by dial.
FREQUENCY RANGE	phase sensitive: single frequency, pre-specified. Total VTVM: 10 cps to 50 kc
RESPONSE	that of selective filters. Function selector switch removes filters in "Total" position for use as conventional broadband VTVM, 10 cps to 50 kc.
SIGNAL INPUT IMPEDANCE	10 megohms direct; 300k ohms with optional shielded isolation transformer at 400 cps
REFERENCE INPUT IMPEDANCE	100,000 ohms, direct or with reference isolation transformer.
REFERENCE VOLTAGE	0.25 to 130 volts variable (with reference isolation transformer, minimum is 1.25 v)
REFERENCE SELECTOR	external reference at rated frequency. Power line reference for 60 cps or 400 cps only, isolated or one side grounded.
CALIBRATION	zero center voltmeter reads rms of sine wave. Linear voltage scales 3-0-3 and 10-0-10. As phase meter reads E cos θ (angle between signal and reference). Phase angle dial calibrated 0 to 90, in 1° divisions. Four position quadrant selector covers 0 to 360°.
OVERLOAD	overload alarm lamp set at 5X full scale voltage
NOISE	less than 5 microvolts with low impedance input
NULLING SENSITIVITY	less than 2.0 microvolts in phase sensitive modes
HARMONIC REJECTION	greater than 55 db with filters
POWER	115 v or 230 v ±10%, 50 to 400 cps. Power cord 6′ long.
SIZE	5¼" high x 19" wide. Removable side brackets permit ready conversion to standard rack mount. Depth 7$\frac{1}{16}$" and width 17¾" behind panel.

VM-202BR (400 cps) base price $735.00, plus options.

OPTIONAL FEATURES / The VM-202 can be supplied, on order, with any of the following optional features: built-in reference isolation transformer; signal isolation transformer with in/out switch: special panel colors; front panel handles; louvered top cover with handles; rear line cord bracket; mirror scale meter; rear electrical connectors. Quotations on special requirements will be promptly supplied.

ACCESSORIES / Accessory modules available for reference and signal isolation and bridging-nulling applications. For data, request Bulletin P-200.

OTHER MODELS / North Atlantic's Phase Angle Voltmeters can be supplied in high sensitivity, transistorized, militarized and broadband types. We invite your inquiries and will be pleased to submit quotations against your specifications.

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NORTH ATLANTIC

THREE FREQUENCY PHASE ANGLE VOLTMETER

MODEL VM-204

FEATURES

- Direct Reading of
  - Total Voltage
  - Fundamental Voltage
  - In-phase Voltage
  - Quadrature Voltage
  - Phase Angle
  - Nulls
- Three Frequency Operation
- Harmonic Rejection
- High Sensitivity

DESCRIPTION

The Model VM-204 Phase Angle Voltmeter is a multi-functional instrument designed to meet laboratory, production line and ground checkout requirements for precise measurement of complex AC signals at any of three customer-specified frequencies. By virtue of its ability to measure the two basic characteristics of any signal—magnitude and phase angle—it readily permits measurements which previously required extensive equipment or which could not be made at all.

The instrument combines in one unit the functions of a sensitive vacuum tube voltmeter, a phase angle meter, a meter measuring in-phase and quadrature signals, a phase-sensitive null detector, an impedance meter and a power factor meter. Voltages, phase angle and nulls are read directly, without the need for accessory equipment. An integral, calibrated phase shifter, adjustable at the front panel, permits direct reading of phase angle with respect to a reference from 0 to 360 degrees without ambiguity.

Since the Model VM-204 Phase Angle Voltmeter will accommodate signals at any of three pre-specified frequencies, as selected by switch, it is ideally suited for production test, and other applications where signals at several known frequencies are repeatedly encountered. Effects of harmonics in any measurement are eliminated by integral selective filters. Exceptionally accurate null indications, such as required for precise measurements of AC voltage ratios, are assured by the instrument's high sensitivity, low internal noise and phase sensitive characteristics. For applications where it is desired to isolate the reference signal, accommodate balanced inputs, or for use of the VM-204 in AC ratiometry, the instrument includes provision for front panel plug-in of isolation, summing and bridging transformer modules, available as optional accessories.

Operating principles and circuit design of the VM-204 are shown in the functional schematic on the reverse side of this bulletin.

TYPICAL APPLICATIONS

In addition to its use as an accurate vacuum tube voltmeter and phase angle meter for circuit development, typical applications of the VM-204 Phase Angle Voltmeter include:

- Production or field test of servos, computers and similar devices.
- Phase sensitive null indication. in association with inductive voltage dividers, for precise AC ratio measurements.
- Zeroing and calibration of high-precision synchros and resolvers.
- Phasing of two-phase servo motors and chopper amplifiers.
- Phase alignment of magnetic amplifier systems where signals are highly distorted. Accurate measurement of both torque- and non-torque-producing signals is readily accomplished.
- Trimming and zeroing of transducers and sensors.
- Alignment of carrier amplifiers and notch networks.

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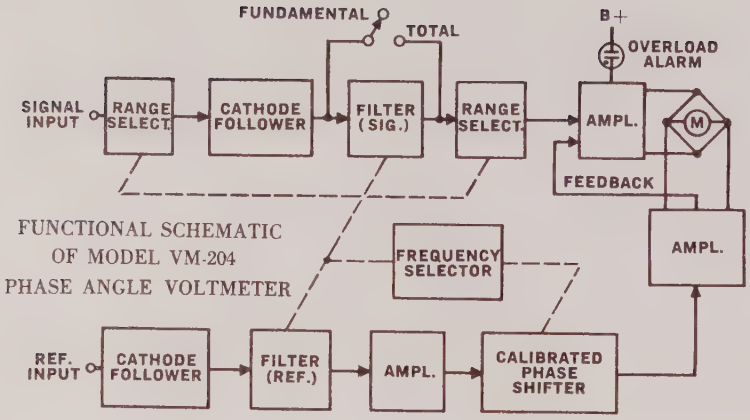
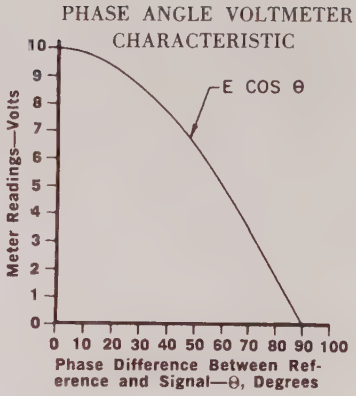


FUNCTIONAL SCHEMATIC OF MODEL VM-204 PHASE ANGLE VOLTMETER


PHASE ANGLE VOLTMETER CHARACTERISTIC
E COS Θ
Meter Readings—Volts
0 1 2 3 4 5 6 7 8 9 10
0 10 20 30 40 50 60 70 80 90 100
Phase Difference Between Reference and Signal—Θ, Degrees

SPECIFICATIONS

VOLTAGE RANGE	1.0 millivolt to 300 volts full scale, in 12 separate ranges.
ACCURACY (AT 400 CPS)	±2% of full scale voltage range. ±3% of full scale degrees as a phase angle meter using E cos Θ characteristic, for up to 5:1 full scale overload. ±1.0° phase angle by dial.
FREQUENCY RANGE	customer option of any 3 frequencies from 60 to 4500 cps. To 10 kc on special order.
RESPONSE	that of selective filters. Function selector switch removes filters in "Total" position for use as broadband conventional VTVM, 10 cps to 50 kc.
INPUT IMPEDANCE	10 megohms
REFERENCE INPUT	100,000 ohms, 0.25 volts min.
CALIBRATION	zero center voltmeter reads rms of sine wave. Linear voltage scales 3-0-3 and 10-0-10 As phase angle meter reads E cos Θ (angle between signal and reference). Phase angle dial calibrated in degrees, with four scales 90 electrical degrees apart.
OVERLOAD	overload alarm lamp set at 5X full scale voltage.
NOISE	less than 5 microvolts
NULLING SENSITIVITY	less than 2.0 microvolts in phase sensitive mode.
HARMONIC REJECTION	55 db with selective filters
POWER	115V ±10%, 60-400 cps, 60 watts (approx) at 60 cps.
SIZE	5¼" high x 19" wide x 9" depth behind panel. Removable side brackets convert unit to standard rack mount.

base price (2 frequencies) $1070.00, plus options.
(3 frequencies) $1190.00, plus options.

ACCESSORIES AND OPTIONAL FEATURES

P-201 Reference Isolation Module: Plug-in unit for applications requiring isolation of the reference channel from the external circuit to eliminate errors from common ground loops and fault currents.

P-202 Precision Resistance Summing Module: Plug-in network, for use in AC ratiometry where polarity of the test piece precludes the use of a bridging transformer and to minimize in-phase ratio errors resulting from quadrature currents flowing through reactive elements in the null circuit.

P-203 Bridging Transformer: Plug-in module, for use in ratio measurements, incorporates special inter-winding electrostatic shield which insures minimum coupling of the primary common mode signal into the secondary.

Optional features of the VM-204, available on order, include: built-in reference isolation transformers; special panel colors; front panel handles; louvered top cover with handles, rear line cord bracket; mirror-scale meter; rear electrical connectors. Quotations on special requirements will be promptly supplied.

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LITHO U.S.A. 6/64

NORTH ATLANTIC

FOUR FREQUENCY PHASE ANGLE VOLTMETER

MODEL VM-214

FEATURES/

* Direct Reading of
  - Total Voltage
  - Fundamental Voltage
  - In-Phase Voltage
  - Quadrature Voltage
  - Phase Angle
  - Nulls
* Solid-State Circuits
* Four Frequency Operation - Plug-In Interchangeability
* ±5% Bandwidth - Without Adjustments
* 300μV Full Scale Sensitivity

The VM-214 Phase Angle Voltmeter represents the latest voltmeter development from the originator of Phase Angle Voltmeters. This instrument features rapid field change of frequency modules with only the most simple of recalibration procedures which consists of adjusting a rear panel phase trim with a common signal to the Signal and Reference terminals. With the use of optional end bells, the same unit is suitable for either rack mounting or bench use.

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SPECIFICATIONS/

Voltage Range	300μv to 300v in 13 ranges
Range Vernier	Adjustable Scaling for Deviation Measurements
Frequency Range	Total Voltage: 10∿ to 100KC Phase Sensitive: 1,2,3,or 4 frequencies from 30∿ to 20KC with plug-in field change (ie. no calibration required)
Phase Sensitive Bandwidth	±5% (Any Phase Sensitive Frequency)
Calibration	Voltage: Zero center meter 3-0-3, 10-0-10 linear scales Phase dial: ·0.5° increments
Accuracy	Voltage: ±2% Full Scale Phase Dial: ±1°
Signal Input Impedance	10 Meg 40μμf
Reference Input Level	.15v to 150v
Reference Input Impedance	10 Meg 40μμf
Overload	10 X overload capability
Noise	less than 5μv
Nulling Sensitivity	less than 0.7μv (phase sensitive)
Harmonic Rejection	55 db
Power	115/230v ± 10% 50 to 440 cps 40 watts
Size	5-1/4"H X 19"W X 12"D
Base Price	$890.00 with a single Plug-In Module set plus $250.00 per additional set supplied with instrument.
Optional End Bells	$35.00/pair

The VM-214 Phase Angle Voltmeter is a standard commercial instrument, and all units are fully wired for 4 frequency operation. They are supplied with 1, 2, 3, or 4 sets of frequency dependent plug-in modules. Any unused positions are left open for field addition, as required. Additional or replacement plug-in frequency modules and harmonic rejection filters are available as a set, and are typically specified as "400∿ Plug-In Module set for VM-214". Panel decals designating frequency are supplied as a part of the set.

Optional Factory-Wired Features:
- Plug-In Reference Isolation
- Plug-In Signal (with DIRECT/TRANS switch) and Reference Isolation
- Special Panels, eg. Paint, Engraving

Other models are available built to MIL-T-21200 Class II.

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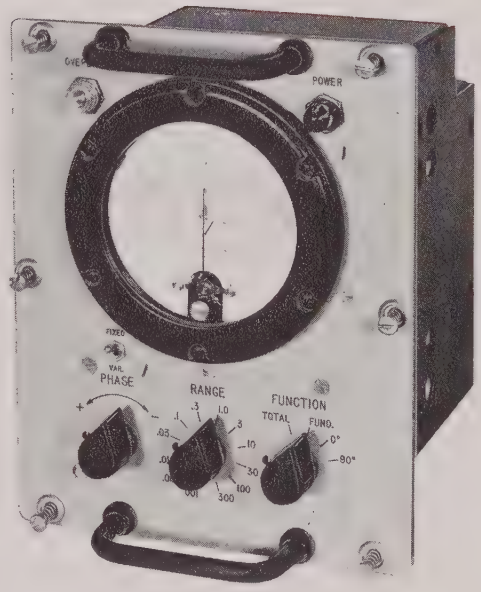
NORTH ATLANTIC

TRANSISTORIZED PHASE ANGLE VOLTMETER

MODEL VM-230

FEATURES

- All solid state circuitry, designed to meet stringent military requirements
- Reads Total, Fundamental, In-Phase, Quadrature Component Voltage, Nulls
- MIL-type, hermetically sealed meter
- Compact rugged design, ideally suited for weapon system and ground support service



DESCRIPTION

An all-transistorized, militarized version of North Atlantic Industries' famous Phase Angle Voltmeter, the Model VM-230 combines in one miniature package all the functions of an a-c voltmeter, phase meter, phase sensitive null indicator, power factor meter and a meter measuring separately the in-phase and quadrature components of a signal. Designed specifically to withstand the wide range of environmental and operating conditions encountered in military ground support equipment, flight test systems and rigorous industrial applications, its small size and electrical and mechanical design make it ideally suited for modular inclusion in panels, consoles and mobile field instrumentation systems.

Design features include a rugged MIL-type, hermetically sealed meter and shielded inputs for signal, reference, power and chassis ground available at the rear connector. Front panel switches permit selection of Total, Fundamental, In-Phase or Quadrature modes of operation. Also included on the front panel are on-off and overload lamps. Guide pins located on the rear permit easy positioning of the VM-230 in mounting panels.

Because the VM-230 is intended for rigorous service under military conditions, special care in design has been used to assure accessibility of all parts for ease of maintenance and repair. Plug-in amplifiers are designed for high reliability and long life.

APPLICATIONS

- Phase-sensitive Null Indicator
- Measures separately the in-phase and quadrature components of an AC signal
- Measures phase angle shift in all AC systems
- Sensitive AC Voltmeter
- Impedance Meter
- Power Factor Meter

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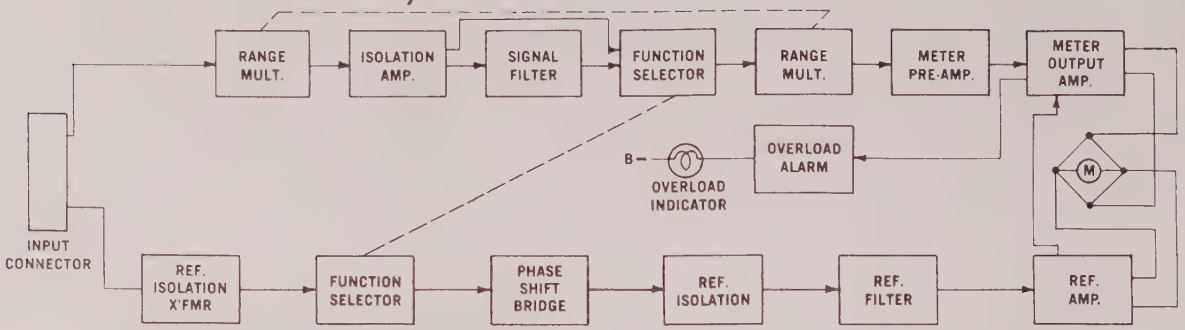
FUNCTIONAL BLOCK DIAGRAM



SPECIFICATIONS

VOLTAGE RANGE	1 mv to 300V full scale in 12 separate ranges with calibrated zero center meter
FREQUENCY RANGE	Standard units available for 400 and 800 cps. Other frequencies available upon request. In Total position unit functions as AC voltmeter from 20 cps to 15 kc
ACCURACY AT RATED FREQUENCY	±3% full scale angle as Phase Angle Voltmeter using E cos Θ characteristic. ±2% full scale as AC voltmeter, 30 cps to 5 kc; ±5% from 20 cps to 15 kc
SIGNAL INPUT IMPEDANCE	1 megohm
REFERENCE INPUT	115 V standard. Other voltages available
CALIBRATION	zero center meter reads rms of sine wave. scales 3-0-3 and 10-0-10 volts. Reads E cos Θ (angle between signal and reference) as phase angle meter. Phase angle switch permits choice of accurately calibrated 0° or 90° reference, or use of variable phase trim. two position quadrant selector selects in-phase or quadrature functions.
OVERLOAD	overload lamp set at 5X full scale voltage, to indicate when fundamental voltage is 5X in-phase voltage being read
NULL SENSITIVITY	2 microvolts in phase sensitive position
NOISE, INTERNAL	less than 2 microvolts (phase sensitive position)
HARMONIC REJECTION	greater than 55 db with filters in phase sensitive position
POWER	115± 10% volts, 50 to 440 cps; approx. 4 watts at 400 cps.
SIZE	panel insert 7⅛″ h. x 5⅜″ w. Depth behind panel 6⅜″. Panel size 8½″ x 7″ w.
WEIGHT	approx. 10 lbs.

base price (400 cps) $1540.00, plus options.

SPECIAL MODELS FOR PARTICULAR REQUIREMENTS

North Atlantic Industries, Inc. currently supplies modified versions of the VM-230 to suit the specific requirements of a number of operational aircraft and missile system ground support equipments. We invite your inquiries regarding special or modified configurations of the VM-230 for particular applications and will be pleased to submit quotations against your specifications.

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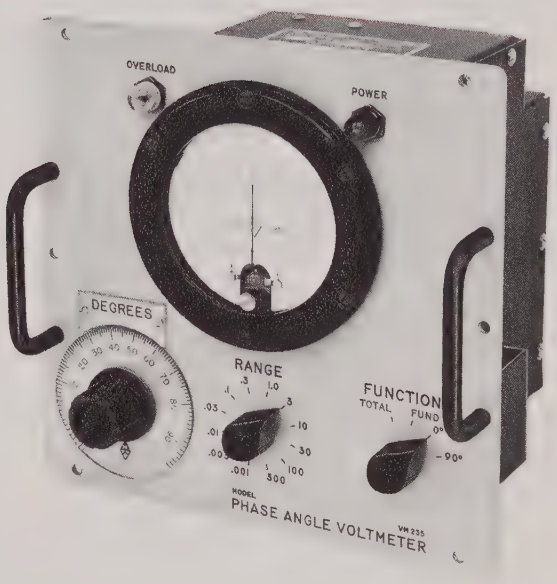
NORTH ATLANTIC

TRANSISTORIZED PHASE ANGLE VOLTMETER

MODEL VM-235

FEATURES

- All solid state circuitry, designed to meet stringent military requirements
- Reads Total, Fundamental, In-Phase, Quadrature Component Voltage, Nulls
- MIL-type, hermetically sealed meter
- Calibrated Phase Shifter for accurate measurement of Phase Angle
- Compact rugged design, ideally suited for weapon system and ground support service



DESCRIPTION

An all-transistorized, militarized version of North Atlantic Industries' famous Phase Angle Voltmeter, the Model VM-235 combines in one miniature package all the functions of an a-c voltmeter, phase meter, phase sensitive null indicator, power factor meter and a meter measuring separately the in-phase and quadrature components of a signal. Designed specifically to withstand the wide range of environmental and operating conditions encountered in military ground support equipment, flight test systems and rigorous industrial applications, its small size and electrical and mechanical design make it ideally suited for modular inclusion in panels, consoles and mobile field instrumentation systems. Design features include a rugged MIL-type, hermetically sealed meter and shielded inputs for signal, reference, power and chassis ground available at the rear connector. A calibrated phase shifter permits direct reading of phase angle between signal and reference vectors for accurate measurement of transformation ratios. Front panel switches permit selection of Total, Fundamental, In-Phase or Quadrature modes of operation. Also included on the front panel are on-off and overload lamps. Guide pins located on the rear permit easy positioning of the VM-235 in mounting panels.

APPLICATIONS

- Phase-sensitive Null Indicator
- Measures separately the in-phase and quadrature components of an AC signal
- Measures phase angle shift in all AC systems
- Sensitive AC Voltmeter
- Impedance Meter
- Power Factor Meter

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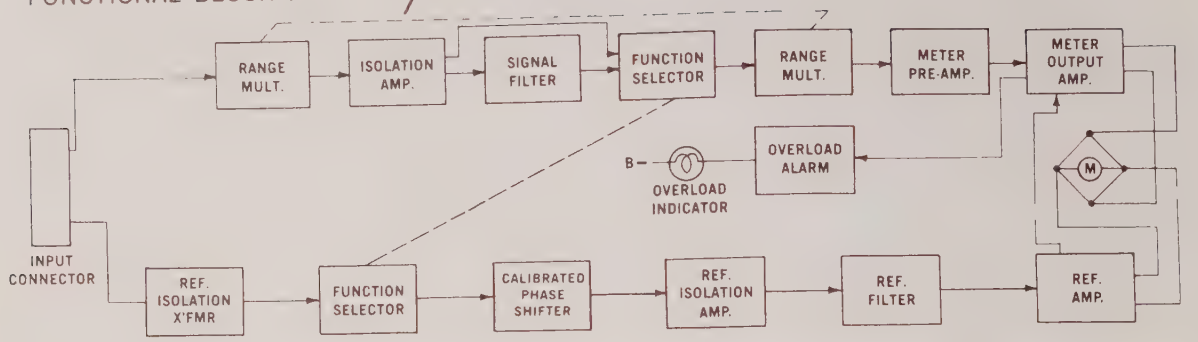
FUNCTIONAL BLOCK DIAGRAM



SPECIFICATIONS

VOLTAGE RANGE	1 mv to 300V full scale in 12 separate ranges with calibrated zero center meter
FREQUENCY RANGE	Standard units available for 400 and 800 cps. Other frequencies available upon request. In Total position unit functions as AC voltmeter from 20 cps to 15 kc
ACCURACY AT RATED FREQUENCY	±3% full scale angle as Phase Angle Voltmeter using E cos Θ characteristic. ±2% full scale as AC voltmeter, 30 cps to 5 kc; ±5% from 20 cps to 15 kc ±1° phase angle by calibrated dial
SIGNAL INPUT IMPEDANCE	1 megohm
REFERENCE INPUT	115 V standard. Other voltages available
CALIBRATION	zero center meter reads rms of sine wave. scales 3-0-3 and 10-0-10 volts. Reads E cos Θ (angle between signal and reference) as phase angle meter. two position quadrant selector selects in-phase or quadrature functions and phase angle dial calibrated in degrees permits 0 to 360° reading.
OVERLOAD	overload lamp set at 5X full scale voltage.
NULL SENSITIVITY	2 microvolts in phase sensitive position
NOISE, INTERNAL	less than 2 microvolts (phase sensitive position)
HARMONIC REJECTION	greater than 55 db with filters in phase sensitive position
POWER	115± 10% volts, 50 to 440 cps; approx. 4 watts at 400 cps.
CONNECTOR	Amphenol #26-159-32
SIZE	panel 8 7/16" H x 8½" W. Depth behind panel 6⅜" Size behind panel 7 1/16" H x 7 3/16" W.
WEIGHT	approx. 10 lbs.

base price (400 cps) $1620.00, plus options.

SPECIAL MODELS FOR PARTICULAR REQUIREMENTS

North Atlantic Industries, Inc. currently supplies modified versions of the VM-235 to suit the specific requirements of a number of operational aircraft and missile system ground support equipments. We invite your inquiries regarding special or modified configurations of the VM-235 for particular applications and will be pleased to submit quotations against your specifications.

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NORTH ATLANTIC

BROAD BAND PHASE ANGLE VOLTMETER

Model VM-301

FEATURES/

*Dynamic Range 10cps to 100kc

*Sweep Measurements Over Half-Decades

*0.25° Accuracy, 0° to 360°

*Nulling Sensitivity 2 microvolts

DESCRIPTION/

The Model VM-301 combines in one integrated instrument a phase sensitive null detector, phase sensitive voltmeter and a phase meter, operating over the frequency range 10cps to 100kc. Its broadband characteristics make it ideally suited for use in amplifier and network design, vibration analysis, telemetry system measurements, bio-medical research, and similar applications requiring the measurement of complex signals and their vector components over a broad range of frequencies.

The Model VM-301 Broadband Phase Angle Voltmeter utilizes passive phase shifter circuits (patents applied for) to assure high accuracy over its operating frequency range. Measurement of in-phase nulls, phase angle, total voltage, fundamental voltage, in-phase voltage, and quadrature voltage at any frequency may be selected by front panel controls. An outstanding feature of the VM-301 is its ability to make phase and vector measurements while sweeping frequency over half-decade spans which are switch selected on the front panel. As a result, the instrument permits rapid determination of phase and gain vs. frequency, and related circuit characteristics both in the laboratory and on the production line.

Maximum harmonic rejection is available through the use of optional signal and reference plug-in filters, which are inserted behind the meter which moves out from the front panel on slides. This permits maximum operator ease and speed when changing filters. Additionally, a front panel Filter IN/OUT switch provides immediate removal from the circuit for the normal broadband operation.

Phase Angle is displayed on a parallax-free scale, calibrated in 0.2° increments. For phase angle measurements requiring highest accuracy, two push and set controls permit trimming to the existing reference frequency to achieve accuracy better than 0.25°. This calibration can be done within 20 seconds by an inexperienced operator. High nulling sensitivity is provided by the instrument's ability to accommodate quadrature overloads up to 10 times the full scale value of the in-phase voltage range in use.

The Model VM-301 has a separate meter for continuous display of the reference signal. The instrument is housed in a rack cabinet, featuring an integral exhaust fan and removable end bells for bench or portable use.

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SPECIFICATIONS/

Voltage Range	1mv to 300v full scale (12 ranges) -60db to +50db (12 ranges)
Phase Angle Range	0° to 360° in 4 quadrants
Frequency Range*	Total Voltage: 10∿ to 100kc Phase Sensitive: 10∿ to 100kc (8 half-decade ranges)
Meter Scale	3-0-3 (60 divisions), 10-0-10 (100 divisions) -14db to +2db
Phase Dial	0° to 90°, 0.2° divisions
Accuracy	Voltage: ±2% full scale over full frequency range
	Phase Angle (using Phase Dial): ±0.25°, 31.6∿ to 31.6kc derating to ±1° at 100kc derating to ±0.6° at 10∿
Overload	10X full scale range setting
Phase Resolution	0.03° at 10X overload
Sweep Frequency Phase Characteristic	2° nominal, 10∿ to 31.6kc 7° nominal, 31.6kc to 100kc (Phase Dial at 0° to 90°)
Input Impedance	Signal & Reference 10 meg, 47μμf nominal(all ranges)
Reference Level	0.15v to 130v
DC Protection	DC may be applied to both signal and reference inputs to 1000v peak for the combined AC and DC voltages
Noise*	10 microvolts (Total Voltage) 2 microvolts (Phase Sensitive)
Non-Coherent Signal	10X full scale range in use at all frequencies ▷5∿ deviation from reference frequency
Harmonic Rejection	Detector characteristics reject all even order harmonics by more than 55db, odd order harmonics in inverse proportion to the harmonic order
Power	115/220v ±10%, 50∿ to 400∿, 80 watts, Fan Cooled
Dimensions & Weight	7"h x 19"w x 11-13/16"d, 32 lbs.
Price	$1990.00

*When plug-in filters are used, the Frequency Range, Noise, and Harmonic Rejection specifications change. Please refer to Data Sheet "VM-301 FILTER DATA" for full supplementary specifications.

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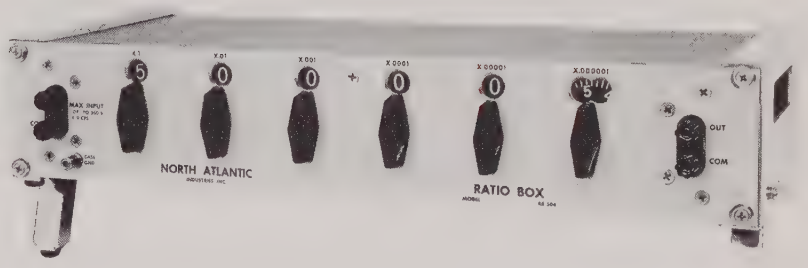
NORTH ATLANTIC

AC RATIO BOXES

MODELS RB-503 & RB-504

FEATURES

- High accuracy at low cost
- Rated accuracy over full ratio range
- Heavy-duty, long-life switches
- No switching transients



DESCRIPTION

Models RB-503 and RB-504 Ratio Boxes are the result of advances in transformer engineering which make possible a group of precision inductive AC voltage dividers providing high accuracy at significantly reduced cost. Designed for either bench or rack-mounted service, they occupy minimum panel space, while providing excellent readability on in-line windowed dials. Both models feature six-digit readout, utilizing five switched decades with switching transient suppression, and a single-turn potentiometer. Heavy-duty rotary switches assure high reliability and long operating life. Transformers meet requirements of MIL-T-27A. In both models fold-away legs are incorporated to facilitate use on the bench, and easily-removed end plates allow quick conversion for rack mounting.

MODEL RB-503

The Model RB-503 provides exceptional performance characteristics at a cost considerably lower than was previously possible. It is ideal for production and inspection testing and for nulling applications. With its high input impedance, low series output impedance, and excellent phase characteristics this model is designed to be used in testing applications where its 10ppm accuracy can be used. The ratio range from zero to 1.111110 enables its use in the majority of applications where ratios greater than unity are encountered.

MODEL RB-504

The Model RB-504 is designed to measure ratios from −0.111110 to +1.111110. It maintains its rated accuracy over this entire ratio range. As a result, measurements about zero and unity are accomplished simply and accurately, eliminating ambiguity and complicated test procedures. Model RB-504 also features high input impedance, low series impedance and exceptionally low phase shift, making it ideally suitable for exacting laboratory, production line, or field test requirements.

APPLICATIONS

Applications of the RB-503 and RB-504 Ratio Boxes include precision calibration of resolvers and synchros where minimum loading, high accuracy and low phase shift are essential; measurement of transformation ratio; zeroing of potentiometers and matching of precision resistors for analog computers. In these and other applications, use of the ratio boxes in conjunction with North Atlantic's Phase Angle Voltmeter permits rapid, direct reading of nulls, phase shift angle and quadrature voltage. Typical test circuits are shown on the reverse of this bulletin.

Models RB-503 and RB-504 are two of North Atlantic's complete line of AC ratio instruments for every measurement and test requirement. Other instruments for AC measurements and precision ratiometry include Series 200 and 300 Phase Angle Voltmeters, Series 400 Phase Sensitive Converters, and Series 500 Complex Voltage Ratiometers and Ratio Boxes.*

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SPECIFICATIONS

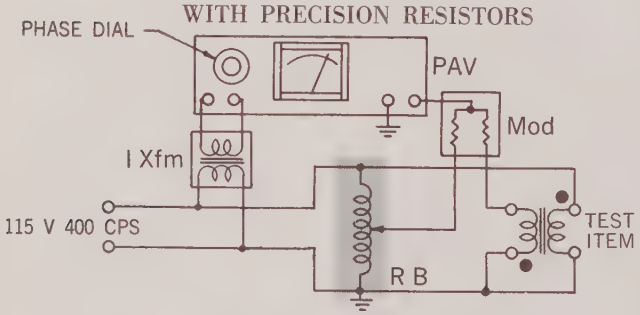
	RB-503	RB-504
RATIO RANGE	0.000000 to +1.111110	−0.111110 to +1.111110
ACCURACY OF RATIO FOR ALL RATIOS FROM 10V. INPUT TO MAX. RATING	±0.001% Terminal Linearity	±0.0001% Terminal Linearity
FREQUENCY RANGE (WITHIN ACCURACY)	50 cps to 5KC	300 cps to 2KC (± 0.0002% T.L. 50 cps to 3KC)
FREQUENCY RANGE (USEFUL)	50 cps to 10KC	50 cps to 10KC
NOMINAL INPUT IMPEDANCE @ 400 CPS	300K	200K
MAX. INPUT VOLTAGE	0.5f Volts (f in cps) (not to exceed 350v)	0.7f Volts (f in cps) (not to exceed 350v)
NOMINAL OUTPUT RESISTANCE (MAX.*)	3.5 ohms	8.5 ohms
PHASE SHIFT	less than 1 min.	less than 1 min.
RESOLUTION	5 decades plus 1 turn potentiometer	5 decades plus 1 turn potentiometer
SWITCHES	heavy duty	heavy duty
SIZE, WEIGHT	3½"h. x 19"w. x 8"d., 15 lbs.	3½" h. x 19"w. x 8"d., 22 lbs
PRICE	$345	$540

Accuracy traceable to National Bureau of Standards.

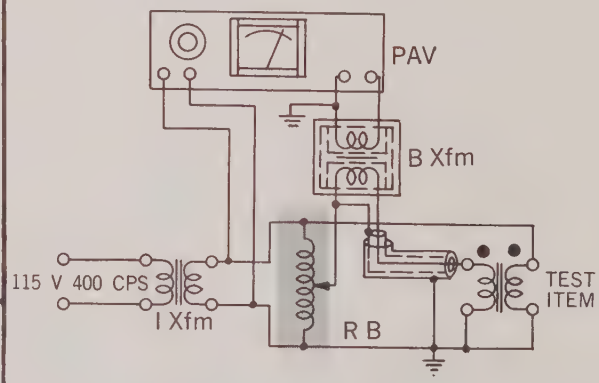
**Varies with ratio setting (peaks at ratio of .555, approximately 0 ohms at ratios of .0 and 1.0).*

TYPICAL APPLICATIONS

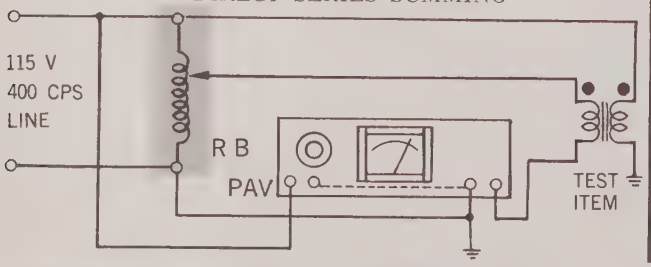
PARALLEL SUMMING WITH PRECISION RESISTORS



SERIES SUMMING WITH BRIDGE-NULL TRANSFORMER



DIRECT SERIES SUMMING



LEGEND

R.B.—Ratio Box
PAV—NORTH ATLANTIC Phase Angle Voltmeter
I Xfm—Isolation Transformer
B Xfm—P-203, T-109, or T-110 Bridge Null Transformer
MOD—P-202 Summing Module

Detailed information on these and other ratio box applications is available on request.

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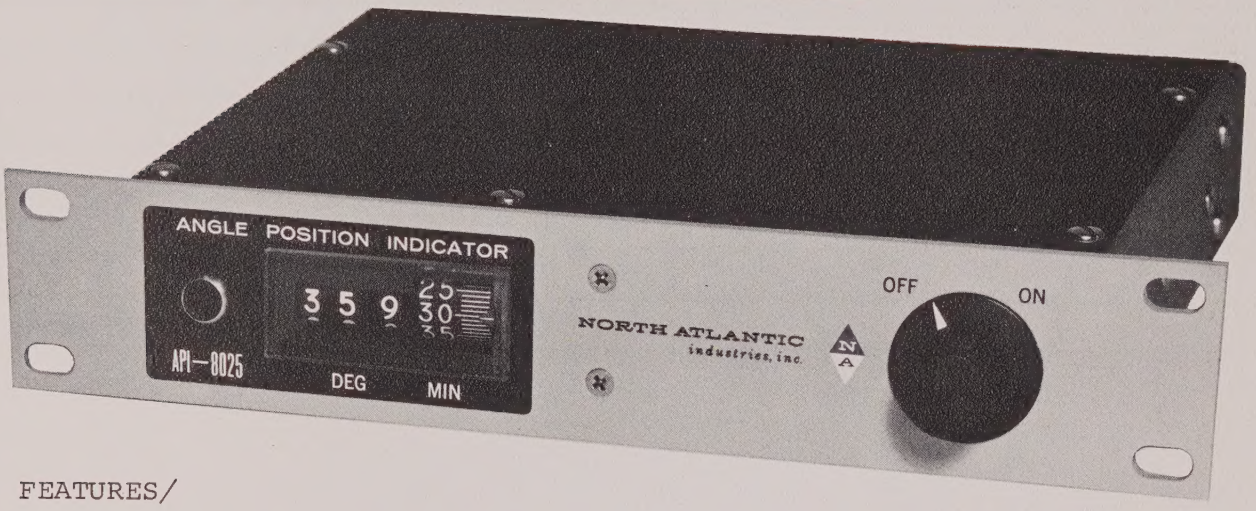
ANGLE POSITION INDICATOR

MODEL API-8025



FEATURES/

* 30 Second Repeatability
* Solid State Plug-in Modules
* Designed to MIL-T-21200
* Many Options Available

DESCRIPTION/

The Model API-8025 Angle Position Indicator is a precision high-speed, militarized, solid-state instrument servo repeater designed to provide a continuous digital readout of the angular shaft position of remote synchro or resolver components. Selection of rotary components and flexibility of design allows accommodation of single or multiple inputs from transmitters, receivers or differential components of any standard voltage or frequency. In addition, a number of retransmit options, such as synchros, potentiometers or shaft encoders, are available. Repeatability and resolution of the Angle Position Indicator is 30 seconds and the accuracy is dependent upon the follow-up component, typically a 6 minute synchro. Other versions provide for D.C. inputs.

The digital readout counter is a special high-speed design providing smooth transition between digits and minimizes peak torque loads reflected back to the gear train.

The servo amplifier, power supply and all optional signal conditioning modules are plug-in, solid-state elements, featuring high stability components and circuitry designed for optimum performance.

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SPECIFICATIONS/

Range	0° to 360° (continuous rotation)
Digital Display	360° 60' (30 second resolution)
Accuracy	6 minutes
Repeatability	30 seconds
Slew Speed	25° per second
Power Requirements	115V, 400 cps, 30 watts maximum
Size	1-3/4"H x 9-1/2"W x 9"D
Weight	3 Lbs.
Price	$895.00 (for 11.8V or 90V 400∿ synchro)

OPTIONS AVAILABLE/

High Accuracy:	4 minutes
Data Input:	Synchro, Resolver or Potentiometer
Multiple Mode Input:	Dual Synchro, Dual Resolver or combinations to 3 components.
Multiple Mode Switching:	Manual or replay programmed.
Multispeed Inputs:	2-speed or 3-speed Synchro.
DC or AC Input:	Ratiometric or Absolute.
Non-Standard Frequencies:	60 cps to 10KC available.
Retransmit Components:	Synchro, resolver, potentiometer or shaft encoder.
Decimal readout:	0-999 counter.
Demodulator/modulator:	To eliminate large quadrature components, hash, or jitter from data input.
Special Panels:	Special paint or engraved.

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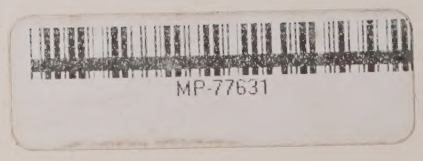
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